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Harry M. Ohlendorf, Erwin E. Klaas,[1] and T. Earl Kaiser

U.S. Fish and Wildlife Service
Patuxent Wildlife Research Center
Laurel, Maryland 20811

Abstract

In 1972 and 1973 we collected 1,339 clutches of eggs of anhingas (*Anhinga anhinga*) and 17 species of waders (herons, egrets, bitterns, ibises, and storks). We analyzed the eggs for organochlorine residues and compared shell thickness of these eggs and others collected since 1946 (and now in museum collections) with shell thickness of eggs collected before the widespread use of organochlorine pesticides.

The overall frequency of residue occurrence was higher in eggs from the Great Lakes region, then in those from the Northern Atlantic Coast, Southern Atlantic Coast, Inland, and Gulf Coast regions. Residue concentrations also were usually higher in eggs from the Northern Atlantic Coast and Great Lakes than in those from the other three regions, but there was no consistent pattern among those three regions. Among species, the highest residue frequencies and concentrations were usually in eggs of great blue herons (*Ardea herodias*), wood storks (*Mycteria americana*), black-crowned night herons (*Nycticorax nycticorax*), and great egrets (*Casmerodius albus*). Lowest frequencies and concentrations were usually in eggs of white ibises (*Eudocimus albus*), glossy ibises (*Plegadis falcinellus*), least bitterns (*Ixobrychus exilis*), green herons (*Butorides striatus*), and yellow-crowned night herons (*Nyctanassa violacea*).

Eggshells were significantly thinner in one or more regions for post-1946 samples of anhinga, great blue heron, black-crowned night heron, and wood stork. We detected no significant change in the other species.

Residues of organochlorine and heavy metal pollutants occur commonly in environmental samples, and these pollutants have been associated with adverse effects in numerous avian species (Cooke 1973; L. F. Stickel 1973; W. H. Stickel 1975; Ohlendorf et al. 1978*a*, 1978*d*). The affected species are usually terminal consumers (i.e., at the top of the food chain), generally those feeding on aquatic organisms (primarily fish) or birds.

Certain herons have been included in general surveys of organochlorine residues in fish-eating birds in the United States and Canada (Keith 1966; Vermeer and Reynolds 1970; Anderson and Hickey 1972; Baetcke et al. 1972). Such residues and their possible effects in herons and related wading birds also have been studied at more restricted localities (Causey and Graves 1969; Greenberg and Heye 1971; Faber et al. 1972; Flickinger and Meeker 1972; Vermeer and Risebrough 1972; Lincer and Salkind 1973). Brown pelicans (*Pelecanus occidentalis*) and double-crested cormorants (*Phalacrocorax auritus*) also have been studied (see Ohlendorf et al. 1978*d* for review), but we found no published information on occurrence or effects of pollutant residues in anhingas (*Anhinga anhinga*) before beginning our study.

Populations of black-crowned night herons (*Nycticorax nycticorax*) (see Ohlendorf et al. 1978*a* for review), great blue herons (*Ardea herodias*), reddish egrets (*Dichromanassa rufescens*), American bitterns (*Botaurus lentiginosus*), wood storks (*Mycteria americana*), white-faced ibises (*Plegadis chihi*), and white ibises (*Eudocimus albus*), have apparently declined, at least in some regions (Bull 1964; Peterson 1969;

[1]Present address: Iowa Cooperative Wildlife Research Unit, Iowa State University, Ames 50010.

Wallace 1969, 1977; Bond 1971; Arbib 1971, 1972, 1973, 1974, 1975, 1976; Ogden 1975, 1978; McWhirter and Beaver 1977).

In 1972, we began a study to determine: (1) geographic differences in the occurrence of environmental pollutants in anhingas and waders in the eastern United States; (2) differences in environmental pollutant concentrations among those species nesting at the same localities; and (3) whether eggshell thickness had changed since the widespread use of organochlorine pesticides began in the mid-1940's.

The wader species included in our study were: great blue heron, green heron (*Butorides striatus*), little blue heron (*Florida caerulea*), cattle egret (*Bubulcus ibis*), reddish egret, great egret (*Casmerodius albus*), snowy egret (*Egretta thula*), Louisiana heron (*Hydranassa tricolor*), black-crowned night heron, yellow-crowned night heron (*Nyctanassa violacea*), least bittern (*Ixobrychus exilis*), American bittern, wood stork, glossy ibis (*Plegadis falcinellus*), white-faced ibis, white ibis, and roseate spoonbill (*Ajaia ajaja*). Our success in collecting eggs of these species varied widely: we were not able to collect any eggs of the reddish egret in either year of our study, and we collected only one clutch of American bittern eggs, but eggs of some other species were collected easily.

A summary of the results of our study has already been published (Ohlendorf et al. 1978*c*). A few minor errors in residue frequencies that appeared in that paper are corrected here in Table 2.

Methods

Eggs were collected at 50 localities in the eastern United States in 1972 and 1973. Seventeen species were represented by a total of 1,339 clutches of eggs.

Entire clutches were collected; when the clutches consisted of two or more eggs, two eggs from each clutch were wrapped in aluminum foil and placed in plastic containers to retard moisture loss. These eggs were refrigerated until they could be processed. Contents were then removed, placed into chemically cleaned jars, and then frozen pending analysis. Only one egg per clutch was analyzed, except those collected at five localities (Rhode Island; Martha's Vineyard, Clark's Island, and House Island, Mass.; and Michigan), from which we analyzed each egg of the black-crowned night heron in all clutches and used arithmetical clutch means in the data tables and comparisons. Shells of all eggs were rinsed gently in tap water and saved for determination of eggshell thickness.

Egg volumes were measured to the nearest 1.0 ml by water displacement before the contents were removed. Residues were adjusted to fresh wet weight, assuming specific gravity of 1.0 as suggested by Stickel et al. (1973).

After egg contents were homogenized in a mixer, a 5- or 10-g subsample was blended with sodium sulfate and extracted 7 to 8 h with hexane in a Soxhlet apparatus. Cleanup of the extract, and separation and quantitation of pesticides and polychlorinated biphenyls (PCB's) were similar to the procedure used for the analysis of eagle carcasses (Cromartie et al. 1975). In summary, a portion of hexane extract equivalent to 5 g of subsample was passed through a Florisil column to remove lipids. An aliquot of this eluate was column chromatographed on silicic acid to separate the pesticides and PCB's. The organochlorines separated into three silicic-acid eluates were identified and quantitated by gas chromatography on a 1.83-m glass column packed with 4% SE-30/6% QF-1 on 100-120 mesh Supelcoport. PCB's were quantitated by comparing total peak area, measured by computing integrator, with that of either Aroclor 1254 or 1260, whichever most closely resembled the gas chromatographic profile of the sample. Residues in 10% of the samples were confirmed with a combined gas

Samples were analyzed for DDE, DDD, DDT, dieldrin, heptachlor epoxide, mirex, oxychlordane, *cis*-chlordane (and/or *trans*-nonachlor), *cis*-nonachlor, HCB, toxaphene, endrin, and PCB's. Chemical names for these compounds are given in Appendix I.

Recoveries of pesticides and PCB's from spiked egg tissue ranged from 83% to 104%. Residues given in this report were not adjusted on the basis of these recoveries. Gas chromatograph sensitivity of detection was 0.1 ppm for pesticides and 0.5 ppm for PCB's. When PCB's were detected in trace amounts (less than 0.5 ppm), they were listed as 0.25 ppm.

A "frequency index" was computed by dividing "total occurrences" by the number of "possible occurrences" to reflect the frequency of organochlorine residue occurrences. Total occurrences are the number of times any of the 13 organochlorines were detected in eggs from that region (or locality); possible occurrences are the number of clutches from that region (or locality) x 13 chemicals.

Mean organochlorine concentrations in the samples were computed on individual sample values (the residue concentration + 1) transformed to common logarithms. The addition of 1 facilitated the transformation of zero values to logs. After computing these values, we took their antilogs and subtracted 1 from that value, which returned our measurements to the original units.

The data were analyzed on a Control Data Corporation 6400 computer, with packaged subroutines from Nie et al. (1975). In some instances the presence of many zero values prevented transformation to the

normal distribution, but we also calculated means of these log-transformed data (see Ohlendorf et al. 1978*a* for further explanation). We performed a one-way analysis of variance (ANOVA) on the log-transformed data for DDE and PCB's to detect significant differences ($P < 0.05$) among the mean levels of these chemicals in eggs of the same species from the different localities (or from different regions) and among different species from the same locality (or region). We used the Scheffé procedure (Scheffé 1959) of multiple comparison of means to group the localities by mean chemical concentration into homogeneous subsets.

Eggshell thickness was measured to the nearest 0.01 mm with a modified Starrett micrometer after the shells had dried at room temperature for at least 1 month. Three measurements were taken at the "equator" of each egg and included the shell and shell membranes. Measurements were averaged to yield a single value for each egg in the clutch, and clutch means were obtained by averaging values for all eggs in the clutch. Statistical testing (two-way, nonrandom model, ANOVA) of eggshell thickness was based on clutch mean thickness.

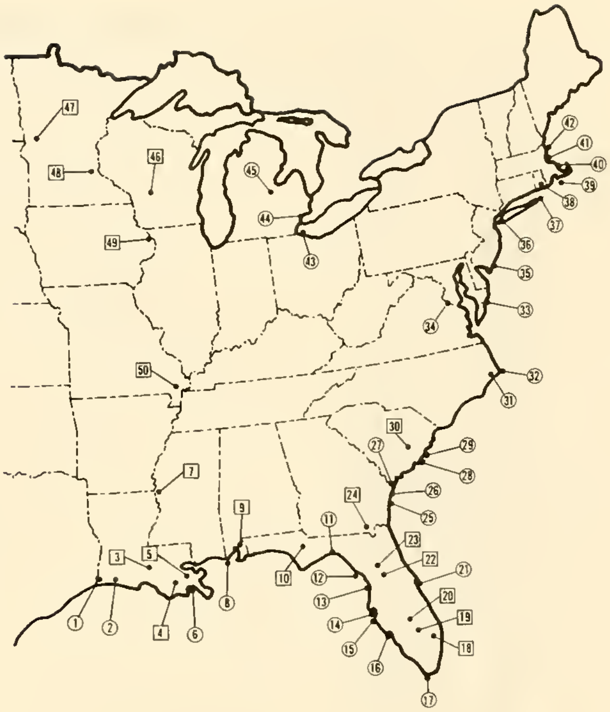

Fig. 1. Collection sites for eggs of anhingas and wading birds, 1972–73. Numbers inside circles indicate coastal and Great Lakes sites; those inside squares indicate Inland sites. Specific locations are identified in Table 1.

Collection Sites

We collected many of the eggs from nesting colonies on or near National Wildlife Refuges (NWR) (Fig. 1 and Table 1) because of logistical considerations and because of the presence of favorable nesting habitat. Samples from refuges are considered to be representative of the general area because herons, ibises, and storks often travel at least several kilometers from the nesting area to feed (Dusi et al. 1971; Custer and Osborn 1978). These birds also disperse widely during the nonbreeding season, but it appears that organochlorine residue levels, at least in black-crowned night heron eggs, reflect contamination levels in the vicinity of the nesting areas (Ohlendorf et al. 1978*a*).

For convenience in discussing geographic variation in occurrence and concentrations of residues, collection sites have been grouped into five major classes or geographic regions: Great Lakes, Northern Atlantic Coast, Southern Atlantic Coast, Gulf Coast, and Inland. Collection sites included in the Great Lakes and Inland regions are freshwater, whereas those referred to as coastal are essentially estuarine. The latter, however, included several sites where herons were nesting at freshwater pools within a few kilometers of tidal waters.

In our treatment of eggshell thickness data, collection sites were grouped into smaller classes than those used in treating residues to avoid obscuring true differences in thickness and to enable more precise testing of geographic variation. The collection site of each clutch of pre-1947 eggs was plotted for each species on an outline map of the United States. This procedure generally resulted in discrete clusters of samples which probably reflected partly the distribution of major heron breeding colonies but also partly the activities of early egg collectors. Eggshell thickness means were calculated from clutch means for each cluster with five or more complete clutches represented. To increase sample sizes, adjoining clusters were pooled if means were obviously similar or if F-tests obtained in ANOVA procedures were nonsignificant ($P > 0.10$). Pooling was not done when biological or ecological information suggested that pooling would be imprudent. For example, shell thickness data for the great white heron (*Ardea herodias occidentalis*) that breeds in the Florida Keys were not pooled with data for nearby populations of great blue heron (*A. h. wardi*) in southern Florida, although pre-1947 shell thickness means for the two subspecific populations were not significantly different.

Thickness data for eggs collected since 1946 were grouped by using the same procedures as for pre-1947 eggs, and the entire data set was subjected to a two-way ANOVA with time and collection site as the two treatment factors. When F-tests for a species were significant for the time factor, thickness means for the

Table 1. *Sites from which eggs of anhingas and wading birds were collected in 1972–73, and numbers of samples (clutches) by species.* See also Fig. 1.

Collection site number	Site (County/Parish) State	Region[a]	Clutches collected for each species[b]																	
			A	GBH	GH	LBH	CE	GE	SE	LH	BCNH	YCNH	LB	AB	WS	GI	WFI	WI	RS	Total
1	Sabine NWR & vicinity (Cameron) La.	GC		2	10	3	2	19	10	8	16		9				10		18	107
2	Lacassine NWR (Cameron) La.	GC	4		7	8				8	10	11								48
3	Atchafalaya Basin (St. Martin) La.	IN	10		10	7		11	2	10	3	10								63
4	Lake Boeuf (Lafourche) La.	IN			10	10			10	10										40
5	Salvador (St. Charles) La.	IN				7	10		7	8										32
6	Barataria Bay (Jefferson & Plaquemine) La.	GC						1	2	10						2	4	6		25
7	Yazoo NWR (Noxubee) Miss.	IN	3				6													9
8	Cat Island (Mobile) Ala.	GC							10	10										20
9	Stapleton (Baldwin) Ala.	IN			1	10	4													15
10	Blountstown (Calhoun) Fla.	IN										10								10
11	St. Marks NWR & vicinity (Wakulla) Fla.	GC			8	10	1		10	11	11	1	2							54
12	Cedar Keys NWR (Levy) Fla.	GC						1	10	2								10		23
13	Chassahowitzka NWR (Citrus & Hernando) Fla.	GC		3				7		5	5									20
14	Tampa Bay (Hillsborough) Fla.	GC				1	3			1								3		8
15	Sarasota Bay (Manatee & Sarasota) Fla.	GC					4	1	2	1								2		10
16	J. N. "Ding" Darling NWR & Charlotte Harbor (Lee & Charlotte) Fla.	GC	11	8	1	10		10	7	10	5							1		63
17	Everglades NP; Frank Key (Monroe) Fla.	GC							2	10								10	6	28
18	Loxahatchee NWR (Palm Beach) Fla.	IN		4																4
19	Lake Okeechobee (Glades) Fla.	IN			3								9							12
20	Lake Istokpoga (Highlands) Fla.	IN				2	10		5	5								11		33
21	Merritt Island NWR (Brevard) Fla.	SA	10	10	10	10	10	13	10	9	9		8		10	5		10		124

Table 1. (continued)

Collection site number	Site (County/Parish) State	Region[a]	Clutches collected for each species[b] A	GBH	GH	LBH	CE	GE	SE	LH	BCNH	YCNH	LB	AB	WS	GI	WFI	WI	RS	Total
22	Orange Lake (Marion) Fla.	IN					10													10
23	Payne's Prairie (Alachua) Fla.	IN	7	3									2							12
24	Okefenokee NWR (Ware) Ga.	IN	1		10	10	10	2	1											34
25	Blackbeard Island NWR (McIntosh) Ga.	SA			1		4	3	6	8	6									28
26	Wassaw NWR (Chatham) Ga.	SA						1	1	1		1								4
27	Savannah NWR (Jasper) S.C.	SA			7	2	1			1										11
28	Drum Island (Charleston) S.C.	SA						1			9	1								11
29	Cape Romain NWR (Charleston) S.C.	SA						11	10	10						5				36
30	Santee NWR (Berkeley) S.C.	IN				10	10													20
31	Mattamuskeet NWR (Hyde) N.C.	SA			3															3
32	Pea Island NWR (Dare) N.C.	SA				6		2	5	6	8					7				34
33	Chincoteague Bay (Worcester & Accomack) Md.-Va.	SA			5	5		7	10	6	12					10				55
34	Potomac River (St. Mary's) Md.	SA			2		10													12
35	Great Egg Harbor & Reeds bays (Cape May & Atlantic) N.J.	SA			1	16		6	11	3	14					15				66
36	Long Island; Jamaica Bay & Jones Beach (King's & Nassau) N.Y.	NA						4	12		19					22				57
37	Gardiner's Island (Suffolk) N.Y.	NA							2		15					4				21
38	Sakonnet River; Gould Island (Newport) R.I.	NA				1			12		26									39
39	Martha's Vineyard; Gay Head & Chappaquiddick (Dukes) Mass.	NA							2		17									19
40	Clark's Island (Plymouth) Mass.	NA									9									9
41	Middle Brewster Island (Suffolk) Mass.	NA									12									12
42	House Island (Essex) Mass.	NA							11		18									29

Table 1. (continued)

Collection site number	Site (County/Parish) State	Region[a]	Clutches collected for each species[b]																	
			A	GBH	GH	LBH	CE	GE	SE	LH	BCNH	YCNH	LB	AB	WS	GI	WFI	WI	RS	Total
43	W. Sister Island & Winous Point (Lucus & Ottawa) Ohio	GL		9							3									12
44	Detroit River (Wayne) Mich.	GL						2			7									9
45	Shiawassee NWR (Saginaw) Mich.	GL		4																4
46	Wyeville (Monroe) Wis.	IN		3																3
47	Pelican Lake (Grant) Minn. Fergus Falls (Otter Tail) Minn. Lake Johanna (Pope) Minn.	IN		8				9			9			1						27
48	Rice Lake (Ramsey) Minn.	IN		2																2
49	Upper Mississippi River Wild Life and Fish Refuge (Jackson) Iowa	IN		2																2
50	Sikeston (Scott) Mo.	IN				10														10
	Totals		46	58	89	138	95	111	170	153	243	34	30	1	10	70	14	53	24	1,339

[a]Codes as follows: IN = Inland; GL = Great Lakes; GC = Gulf Coast; SE = Southern Atlantic (Fla.-N.J.); NA = Northern Atlantic (N.Y.-Mass.)
[b]Codes as follows: A = anhinga; GBH = great blue heron; GH = green heron; LBH = little blue heron; CE = cattle egret; GE = great egret; SE = snowy egret; LH = Louisiana heron; BCNH = black-crowned night heron; YCNH = yellow-crowned night heron; LB = least bittern; AB = American bittern; WS = wood stork; GI = glossy ibis; WFI = white-faced ibis; WI = white ibis; RS = roseate spoonbill.

two periods (pre-1947 vs. 1947-1973) were tested for differences by individual *t*-tests (two-tailed) within each site group. Estimates of variances and degrees of freedom for calculating *t*-values were obtained from the ANOVA.

Organochlorine Residues

The most commonly detected pollutant was DDE, PCB's were second, and dieldrin was third (Table 2). Each chemical was found in at least two of the eggs; endrin was found least often. Both frequency of occurrence and concentration of residues in the eggs differed geographically and by species, apparently reflecting non-uniform distribution of organochlorines in the environment and dissimilar feeding habits of the species.

Highest mean concentrations of DDE (18.0 ppm), DDT (1.4 ppm), HCB (0.79 ppm), and PCB's (29.0 ppm) were in great blué heron eggs from Shiawassee NWR, Mich. Dieldrin (3.3 ppm), heptachlor epoxide (0.36 ppm), and *cis*-nonachlor (0.081 ppm) concentrations were highest in great blue heron eggs from Iowa, and *cis*-chlordane (0.67 ppm) was highest in great blue heron eggs from Ohio.

The concentration of DDD (2.0 ppm) was highest in snowy egret eggs from Gardiner's Island, N.Y. Mean concentration of oxychlordane (0.21 ppm) was highest in snowy egret eggs from Sarasota Bay, Fla.

The highest mean concentration of mirex (0.74 ppm) was found in green heron eggs from Savannah NWR, S.C.; the only cattle egret egg analyzed from there contained 2.9 ppm mirex. Toxaphene (0.19 ppm) was highest in cattle egret eggs from Yazoo NWR, Miss.

Endrin was detected only in great egret eggs from the Atchafalaya Basin, La.; mean concentration in those eggs was 0.016 ppm.

Geographic Differences

Frequency of Residue Occurence

When considering all chemicals and all species, organochlorine residues occurred more frequently in eggs from the Great Lakes (frequency index 0.492) than in eggs from any other region. (The index presents the actual number of residue occurrences as a proportion of the possible occurrences, computed as shown in Table 2.) Detectable residues also were more frequent in eggs from the Northern Atlantic Coastal colonies (0.374) than in all regions combined (0.212). Residues occurred with lowest frequency in eggs from the Gulf Coast nesting colonies (0.155).

Unlike most other chemicals, heptachlor epoxide was less frequently detected in the Southern Atlantic samples (0.5%) than in those from the Inland (4.1%) or Gulf Coast (2.0%) regions (Table 2). Mirex was more common in eggs from the Great Lakes (24.0%) than in those from the two southern coastal regions (15.6% and 4.4%) and the Inland (10.7%) areas. Oxychlordane was found somewhat more commonly in samples from the Northern Atlantic region (38.7%) than in those from the Great Lakes (24.0%), but HCB was much more frequently detected in the Great Lakes samples (40.0%) than in those from any other region. Toxaphene and endrin were the only organochlorines not detected in any eggs from the Northern Atlantic Coastal sites.

In certain species, the frequency of residue occurrence by regions was substantially different from the overall pattern for all species combined (Table 2 and Appendix II). For example, the frequencies of organochlorines in eggs of anhinga (index = 0.165; Ohlendorf et al. 1978*b*), great blue heron (0.350; Appendix II-A), and great egret (0.371; Appendix II-E) from Inland sites were higher than for Southern Atlantic samples (0.123, 0.269, and 0.253, respectively), and frequencies in eggs of snowy egret (0.190; Appendix II-F) and least bittern (0.112; Appendix II-J) from the Gulf Coast were slightly higher than that for Southern Atlantic (0.183; 0.106) and Inland (0.169; 0.084) samples. Frequencies in eggs of black-crowned night heron (0.173; Ohlendorf et al. 1978*a*; recomputed on basis of 13 chemicals), cattle egret (0.192; Appendix II-D), and white ibis (0.103; Appendix II-N) from Gulf Coast sites were higher than in eggs of these species from Inland areas (0.141, 0.179, 0.063).

Among the individual collection sites, the overall frequency of organochlorine residue occurrence (i.e., when all species were included) was consistently high (frequency index > 0.250) at each site in the Northern Atlantic and Great Lakes regions; the notable exception was Martha's Vineyard, Mass. (Fig. 2).

Overall frequency in New Jersey samples (0.249) was higher than at any other Southern Atlantic site, and further reflects the increasing frequency of occurrence in northern coastal areas (Fig. 2). Frequency of occurrence also was high (> 0.250) at four sites where two or more species were sampled (Yazoo NWR, Miss.; Sarasota Bay, Fla.; Santee NWR, S.C.; and Pelican Lake-Lake Johanna, Minn.) and four where only great blue heron eggs were collected (Loxahatchee NWR, Fla.; Wyeville, Wis.; Rice Lake, Minn.; and Iowa).

Frequency of residue occurrence was low (< 0.125) at six sites where two or more species were sampled (Salvador, La.; Chassahowitzka NWR, Everglades NP, Lake Okeechobee, and Lake Istokpoga, Fla.; and Okefenokee NWR, Ga.) and at Blountstown, Fla., where only yellow-crowned night heron eggs were collected (Fig. 2).

Table 2. *Frequencies of organochlorine residues in eggs of anhingas and wading birds (all species; by region), 1972-73.*

	Number (percent) with residues					
Compound	Great Lakes (*N*=25)	Northern Atlantic[a] (*N*=186)	Southern Atlantic[b] (*N*=384)	Inland (*N*=338)	Gulf Coast (*N*=406)	Total (*N*=1,339)
DDE	25 (100)	186 (100)	379 (98.7)	316 (93.5)	386 (95.1)	1,292 (96.5)
DDD	21 (84.0)	101 (54.3)	36 (9.4)	31 (9.2)	30 (7.4)	219 (16.4)
DDT	10 (40.0)	89 (47.8)	82 (21.4)	73 (21.6)	31 (7.6)	285 (21.3)
Dieldrin	23 (92.0)	124 (66.7)	105 (27.3)	94 (27.8)	88 (21.7)	434 (32.4)
Heptachlor epoxide	5 (20.0)	11 (5.9)	2 (0.5)	14 (4.1)	8 (2.0)	40 (3.0)
Mirex	6 (24.0)	6 (3.2)	60 (15.6)	36 (10.7)	18 (4.4)	126 (9.4)
Oxychlordane	6 (24.0)	72 (38.7)	20 (5.2)	20 (5.9)	22 (5.4)	140 (10.5)
Cis-chlordane[c]	22 (88.0)	124 (66.7)	39 (10.2)	25 (7.4)	33 (8.1)	243 (18.1)
Cis-nonachlor	3 (12.0)	14 (7.5)	3 (0.8)	8 (2.4)	5 (1.2)	33 (2.5)
HCB	10 (40.0)	5 (2.7)	1 (0.3)	12 (3.6)	0	28 (2.1)
Toxaphene	4 (16.0)	0	5 (1.3)	18 (5.3)	0	27 (2.0)
Endrin	0	0	0	2 (0.6)	0	2 (0.1)
PCB's	25 (100)	172 (92.5)	285 (74.2)	141 (41.7)	195 (48.0)	818 (61.1)
Total occurrences	160	904	1,017	790	816	3,687
Frequency index[d]	0.492	0.374	0.204	0.180	0.155	0.212

[a]Coastal colonies from New York to Massachusetts.
[b]Coastal colonies from Florida to New Jersey.
[c]Or *trans*-nonachlor, or both.
[d]Computed as: $\frac{\text{Total occurrences}}{\text{Possible occurrences.}}$

Total occurrences = number of times any of the 13 organochlorines were detected in eggs from that region. Possible occurrences = number of clutches from that region × 13 chemicals.

Residues of DDE were detected in all eggs of all species from the Great Lakes, northern Inland, and Atlantic Coastal sites except Merritt Island NWR, Fla., where it occurred in 96% of the samples (see Appendix III for specific data on each species, locality, and chemical). DDE occurred in 90-100% of the samples at each Gulf Coast or southern Inland site except for six (Salvador, La.; Stapleton, Ala.; Chassahowitzka NWR, Everglades NP, and Lake Istokpoga, Fla.; and Okefenokee NWR, Ga.), where it occurred in less than 90% of the eggs.

Residues of DDD usually were found in more than half of the eggs of all species at each coastal locality from New Jersey northward (except Martha's Vineyard, Mass., where it was only 15.8%) and at each Great Lakes locality. DDD was also detected in 55% of the samples from Yazoo NWR, Miss., but only nine eggs from there were analyzed. Frequency of DDD was less than 50% at other collection sites.

Residues of DDT occurred in more than 25% of the eggs from Pea Island NWR, N.C., and coastal sites farther north, and in samples from four Inland sites (Atchafalaya Basin, La.; Yazoo NWR, Miss.; Santee NWR, S.C.; and Missouri).

Dieldrin was detected in more than 35% of the total samples from Sabine NWR, Lacassine NWR, and Atchafalaya Basin, La.; Sarasota Bay, Fla.; Savannah NWR, Cape Romain NWR, and Santee NWR, S.C.; Potomac River, Md.; and all Northern Atlantic Coastal, Great Lakes, and northern Inland collection sites.

Heptachlor epoxide usually was found in only one or two species per site without a clear geographic pattern, except for its generally more frequent occurrence in samples from the Great Lakes and less frequent occurrence in those from the Southern Atlantic Coastal localities.

Mirex occurred more frequently in the samples (usually more than 30% of all samples) from Tampa Bay and Sarasota Bay, Fla., and from central Florida through South Carolina (including all of those collected at Savannah NWR, S.C.). It also was found in many of the eggs from the individual Great Lakes sites and in eggs of cattle egrets from three Inland sites (Salvador, La.; Yazoo NWR, Miss; and Stapleton, Ala.).

Oxychlordane was detected in more than 15% of the total samples from six southern collection sites (Yazoo NWR, Miss.; Stapleton, Ala.; Tampa Bay, Sarasota Bay, and Payne's Prairie, Fla.; and Drum Island, S.C.), from each Northern Atlantic Coastal site, and from Ohio, Iowa, and Shiawassee NWR, Mich.

Cis-chlordane occurred in more than 20% of the eggs from four southern sites (Sarasota Bay, Loxahatchee

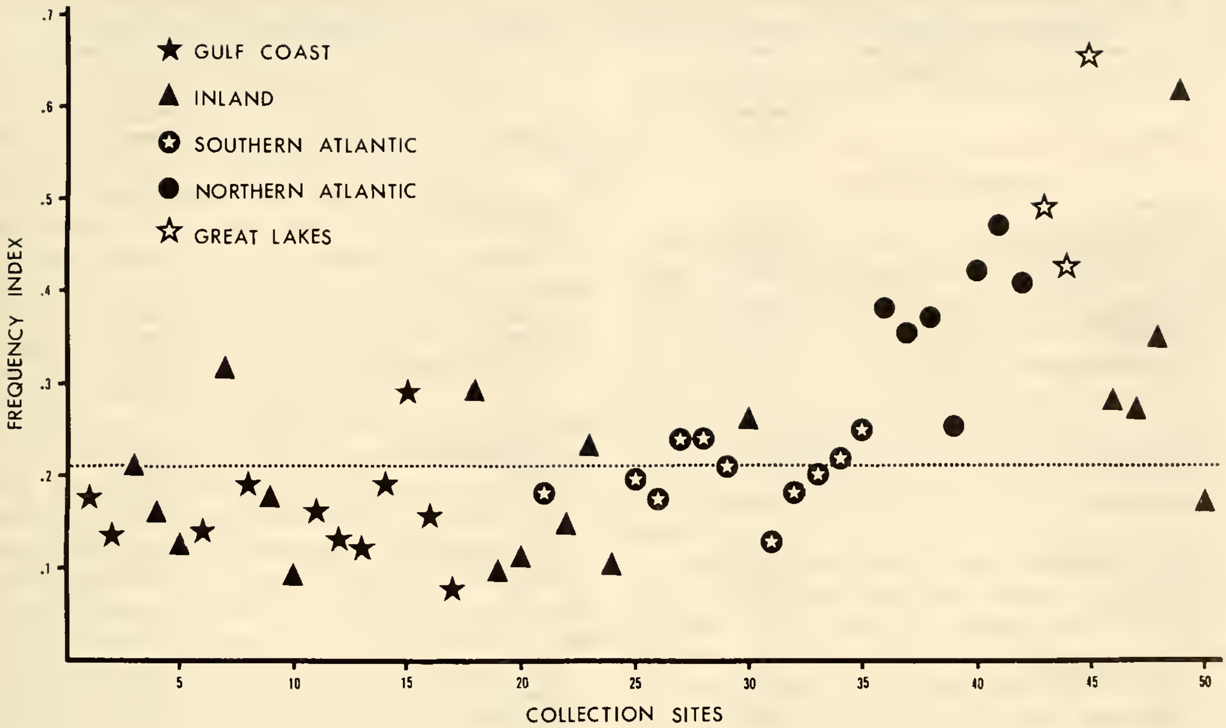

Fig. 2. Frequency of organochlorine residue occurrence in eggs of anhingas and wading birds, 1972–73, by collection sites and region. Overall mean frequency index (0.212) is based on all eggs analyzed in the study (1.339 clutches).

NWR, and Payne's Prairie, Fla.; and Drum Island, S.C.), and each Northern Atlantic Coastal and Great Lakes site, Iowa, and Pelican Lake-Lake Johanna, Minn. Its frequency approached 20% in samples from Darling NWR, Fla., and New Jersey.

Cis-nonachlor was found in less than 10% of the eggs from each collection site except three in the South (Yazoo NWR, Miss.; Stapleton, Ala.; and Sarasota Bay, Fla.); Rhode Island; Middle Brewster Island, Mass.; Ohio; Shiawassee NWR, Mich.; and Iowa. Although *cis*-nonachlor did occur at 11 other sites, it was found in only one or two eggs at each.

Residues of HCB occurred in the samples from Iowa, Merritt Island NWR, Fla., the three inland Louisiana sites, two inland Minnesota sites, and several Northern Atlantic Coastal and Great Lakes sites. It usually occurred in less than 10% of the eggs.

Toxaphene was widely distributed in the Inland and Great Lakes regions, occurring in a few samples at most of those collection sites. Except for Merritt Island NWR, Fla. (where it occurred in great blue heron and wood stork eggs), it was not detected in eggs from coastal sites.

Endrin was found only in two eggs of great egrets from the Atchafalaya Basin, La.

Residues of PCB's were found in more than 85% of all samples from Chincoteague Bay, Md.-Va., and each coastal site farther north. They occurred in all of the eggs from each site in Massachusetts, the Great Lakes region, and in two southern coastal sites (Cat Island, Ala., and Drum Island, S.C.) that are near large industrialized areas. In addition, PCB's occurred in all of the eggs collected at four other collection sites where only great blue herons were sampled (Loxahatchee NWR, Fla.; Wyeville, Wis.; Rice Lake, Minn.; and Iowa).

Residue Concentration

Within species, there were often significant differences ($P < 0.05$) among regional means for DDE and PCB's (Table 3); mean residue levels for other chemicals were not tested. Means were always higher in the samples from the Great Lakes or Northern Atlantic regions than in those from other regions. Differences among the other regions were not consistent,

Table 3. *Mean DDE and PCB residue concentrations (ppm, wet weight) in eggs of anhingas and wading birds, 1972-73, ranked by region within species. Only species collected in more than one region are included.*

DDE		PCB's	
Region	Geometric[a] mean	Region	Geometric[a] mean
		Anhinga	
Inland	1.61 A	Southern Atlantic	1.07 A
Gulf Coast	0.50 B	Inland	0.32 AB
Southern Atlantic	0.39 B	Gulf Coast	0.15 B
		Great blue heron	
Great Lakes	6.76 A	Great Lakes	13.65 A
Inland	3.90 AB	Inland	2.95 B
Southern Atlantic	2.13 AB	Southern Atlantic	2.42 B
Gulf Coast	1.39 B	Gulf Coast	1.70 B
		Green heron	
Southern Atlantic	0.79 A	Southern Atlantic	0.27 A
Inland	0.70 A	Inland	0.15 A
Gulf Coast	0.42 A	Gulf Coast	0.07 A
		Little blue heron	
Southern Atlantic	0.92 A	Southern Atlantic	1.37 A
Inland	0.82 A	Inland	0.28 B
Gulf Coast	0.34 B	Gulf Coast	0.14 B
		Cattle egret	
Southern Atlantic	1.04 A	Southern Atlantic	0.37 A
Inland	0.88 A	Inland	0.14 AB
Gulf Coast	0.35 A	Gulf Coast	0.0 B
		Great egret	
Inland	2.06 A	Inland	1.44 A
Southern Atlantic	1.82 A	Southern Atlantic	1.32 A
Gulf Coast	0.74 B	Gulf Coast	0.35 B
		Snowy egret	
Northern Atlantic	2.66 A	Northern Atlantic	5.00 A
Southern Atlantic	1.12 B	Southern Atlantic	0.90 B
Gulf Coast	0.80 B	Gulf Coast	0.78 B
Inland	0.80 B	Inland	0.60 B
		Louisiana heron	
Inland	0.73 A	Inland	0.70 A
Southern Atlantic	0.59 A	Gulf Coast	0.61 A
Gulf Coast	0.56 A	Southern Atlantic	0.49 A
		Black-crowned night heron	
Northern Atlantic	4.75 A	Northern Atlantic	8.73 A
Great Lakes	2.96 AB	Great Lakes	7.10 A
Southern Atlantic	1.86 BC	Southern Atlantic	1.77 B
Gulf Coast	0.82 C	Gulf Coast	0.39 C
Inland	0.71 C	Inland	0.31 C
		Yellow-crowned night heron	
Inland	0.59 A	Gulf Coast	0.0 A
Gulf Coast	0.16 A	Inland	0.0 A
		Least bittern	
Inland	0.96 A	Southern Atlantic	0.17 A
Gulf Coast	0.46 B	Gulf Coast	0.07 A
Southern Atlantic	0.29 B	Inland	0.0 A
		Glossy ibis	
Northern Atlantic	1.64 A	Northern Atlantic	0.50 A
Southern Atlantic	1.46 A	Southern Atlantic	0.14 A
		White ibis	
Southern Atlantic	0.27 A	Southern Atlantic	0.21 A
Gulf Coast	0.19 A	Gulf Coast	0.08 AB
Inland	0.14 A	Inland	0.0 B

[a]For each species, regional means that do not share the same letters are significantly different ($P < 0.05$) from each other (DDE and PCB's considered separately). Means of 0.0 ppm reflect that PCB's were not detected in certain regions for that species.

probably in part because all of the species usually were not collected at the same nesting colonies. Particularly among the Inland sites, residues in the eggs seemed to reflect local usage of organochlorines; residue concentrations of pesticides and their metabolites in eggs from Inland colonies were often higher than in those from nearby coastal sites (Table 4 and Appendix III).

In the Inland region, mean DDE concentrations for each species were higher than the mean PCB levels. However, among the other regions (particularly the Great Lakes and Northern Atlantic), PCB concentrations were often greater than DDE. This difference probably reflects agricultural use of DDT in the Inland areas and the industrial sources of PCB's in the Great Lakes and Northern Atlantic regions.

Mean residue concentrations of DDE (18.0 ppm) and PCB's (29.0 ppm) were higher in great blue heron eggs from Shiawassee NWR, Mich., than in any other samples we analyzed (Table 4 and Appendix III). Mean DDE residue levels for most species were lowest in the eggs from the various Gulf Coast sites; the exception was St. Marks NWR, Fla., where snowy egrets, Louisiana herons, and least bitterns had somewhat higher residue concentrations than at most other sites where their eggs were collected. Although there were exceptions, mean PCB concentrations for most species were lowest in the samples from Atlantic Coastal sites south of Virginia and from Inland and Gulf Coast sites. The most consistent exception was that PCB concentrations in eggs from Merritt Island NWR, Fla., tended to be relatively high. PCB levels in eggs of one or more of the species were relatively high at the Atchafalaya Basin, Salvador, and Barataria Bay, La.; Yazoo NWR, Miss.; Cat Island, Ala.; and St. Marks NWR, Fla. (when compared with means at other sites for these species).

In comparing eggs of all species collected at both locations (great egret, snowy egret, black-crowned night heron, and glossy ibis), concentrations of PCB's were much higher (usually at least double) in eggs from Long Island, N.Y., than in those from New Jersey. Concentrations in the eggs from New Jersey also were higher than (sometimes twice that) in those from Chincoteague Bay, Md.-Va. In black-crowned night herons, DDE levels followed the same pattern (Ohlendorf et al. 1978*a*).

Among the collection sites, PCB/DDE ratios tended to be higher than 1.0 in samples from New Jersey northward along the coast (except for Gardiner's Island, N.Y.) and from Great Lakes sites than in other samples (Appendix III). The ratio also exceeded 1.0 in one or two species at several sites in the other regions, particularly in eggs of the snowy egret (Appendix III-F) and Louisiana heron (Appendix III-G) from the Gulf Coast and Louisiana Inland sites. Among the Southern Atlantic sites, the PCB/DDE ratio in samples from Merritt Island NWR, Fla., was greater than 1.0 in seven species; in the other species the ratio usually was higher in samples from Merritt Island than at other sites in the three southern regions, although the ratio did not exceed 1.0.

Species Differences

Eggs of the great blue heron (frequency index 0.359), wood stork (0.331), black-crowned night heron (0.309), and great egret (0.265) usually had the greatest frequency of residue occurrence and the highest mean concentrations (Table 5 and Appendix II; also Ohlendorf et al. 1978*a*, 1978*b*). Eggs of green heron (0.118), white-faced ibis (0.115), white ibis (0.100), least bittern (0.100), and yellow-crowned night heron (0.095) usually had the lowest frequencies and mean concentrations.

Although the overall frequency of residue occurrence in glossy ibis eggs (0.224; Appendix II-L) was considerably higher than in eggs of other ibises, many of the glossy ibis eggs were collected at Northern Atlantic sites. Among the species from those sites, residues were less frequent and at lower concentrations in the glossy ibis eggs than in other species.

Endrin was detected in great egret eggs (from the Atchafalaya Basin, La.), but not in any other species. It was the only chemical not detected in great blue heron, little blue heron, and cattle egret eggs.

Frequency of Residue Occurrence

For each chemical except DDT, overall frequency of occurrence (i.e., when all collection sites were included) was higher in great blue herons than the average for all species combined (Table 2 and Appendix II-A). Within the Southern Atlantic, Inland, and Gulf Coast regions, the frequency was often at least twice the average.

Except for DDE, mirex, and *cis*-nonachlor, frequency of all chemicals in green heron eggs was considerably lower than the average for all species combined (Table 2 and Appendix II-B). Mirex was unusually common in green heron samples from the Southern Atlantic region. However, all seven green heron eggs from that region that contained mirex were from Savannah NWR, S.C.; all eggs of other species collected there also contained mirex. However, mirex was not found in green heron eggs from the Inland region, where overall frequency in all species combined averaged 10.7%. *Cis*-nonachlor was found in only one green heron egg from the Atchafalaya Basin, La.; heptachlor epoxide, HCB, toxaphene, and endrin were not detected. Frequency of PCB's was usually less than half the average for all species combined.

Frequencies of most chemicals in little blue heron eggs were below the averages for all species combined,

Table 4. *Mean DDE and PCB residue concentrations (ppm, wet weight) in eggs of anhingas and wading birds, 1972–73, ranked by collection site within species. Only species collected at more than one site are included.*

DDE		PCB's	
Site	Geometric[a] mean	Site	Geometric[a] mean
	Anhinga		
Yazoo NWR, Miss.	3.5	Merritt Is. NWR, Fla.	1.1 A
Atchafalaya Basin, La.	2.1	Payne's Prairie, Fla.	0.58 A
Lacassine NWR, La.	0.79	Okefenokee NWR, Ga.	0.25
Payne's Prairie, Fla.	0.76 AB	Atchafalaya Basin, La.	0.23 A
Okefenokee NWR, Ga.	0.42	J.N. "Ding" Darling NWR, Fla.	0.21 A
J.N. "Ding" Darling NWR, Fla.	0.41 B	Yazoo NWR, Miss.	0.11
Merritt Is. NWR, Fla.	0.39 B	Lacassine NWR, La.	0.0
	Great blue heron		
Shiawassee NWR, Mich.	18.0	Shiawassee NWR, Mich.	29.0
Loxahatchee NWR, Fla.	12.0	Ohio	9.6 A
Rice Lake, Minn.	7.0	Iowa	8.1
Iowa	4.2	Payne's Prairie, Fla.	6.5
Ohio	4.2 A	Rice Lake, Minn.	5.5
Sabine NWR, La.	3.8	J.N. "Ding" Darling NWR, Fla.	2.6 AB
Wyeville, Wis.	3.3	Wyeville, Wis.	2.5
Pelican Lake, Minn.	2.2 A	Merritt Is. NWR, Fla.	2.4 B
Payne's Prairie, Fla.	2.2	Pelican Lake, Minn.	1.9 B
Merritt Is. NWR, Fla.	2.1 A	Loxahatchee NWR, Fla.	1.5
J. N. "Ding" Darling NWR, Fla.	1.4 A	Sabine NWR, La.	1.2
Chassahowitzka NWR, Fla.	0.46	Chassahowitzka NWR, Fla.	0.43
	Green heron		
Savannah NWR, S.C.	1.4 A	Potomac River, Md.	1.6
Atchafalaya Basin, La.	1.3 A	Atchafalaya Basin, La.	0.6 A
Chincoteague Bay, Md.-Va.	1.1 A	Merritt Is. NWR, Fla.	0.44 A
New Jersey	0.77	New Jersey	0.25
Blackbeard Is. NWR, Ga.	0.62	Chincoteague Bay, Md.-Va.	0.23 A
Lake Okeechobee, Fla.	0.56	St. Marks NWR, Fla.	0.15 A
Stapleton, Ala.	0.56	Sabine NWR, La.	0.077 A
Potomac River, Md.	0.51	Savannah NWR, S.C.	0.0 A
Okefenokee NWR, Ga.	0.50 A	Blackbeard Is. NWR, Ga.	0.0
Lake Boeuf, La.	0.49 A	Lake Okeechobee, Fla.	0.0
Merritt Is. NWR, Fla.	0.49 A	Stapleton, Ala.	0.0
Mattamuskeet NWR, N.C.	0.47	Okefenokee NWR, Ga.	0.0 A
Lacassine NWR, La.	0.47 A	Lake Boeuf, La.	0.0 A
Sabine NWR, La.	0.41 A	Mattamuskeet NWR, N.C.	0.0
St. Marks NWR, Fla.	0.40 A	Lacassine NWR, La.	0.0 A
J.N. "Ding" Darling NWR, Fla.	0.28	J.N. "Ding" Darling NWR, Fla.	0.0
	Little blue heron		
Chincoteague Bay, Md.-Va.	1.9 A	Lake Istokpoga, Fla.	8.4
Santee NWR, S.C.	1.6 A	Tampa Bay, Fla.	3.2
Lake Istokpoga, Fla.	1.5	New Jersey	3.1 A
Missouri	1.4 A	Gould Island, R.I.	2.8
Gould Island, R.I.	1.3	Sabine NWR, La.	1.6
New Jersey	1.2 A	Savannah NWR, S.C.	1.4
St. Marks NWR, Fla.	0.87 A	Chincoteague Bay, Md.-Va.	0.83 AB
Atchafalaya Basin, La.	0.82 A	Merritt Is. NWR, Fla.	0.54 B
Pea Is. NWR, N.C.	0.81 A	Lake Boeuf, La.	0.50 B
Lake Boeuf, La.	0.68 A	Santee NWR, S.C.	0.47 B
Stapleton, Ala.	0.50 A	Stapleton, Ala.	0.42 B
Okefenokee NWR, Ga.	0.46 A	Pea Is. NWR, N.C.	0.35 B
Savannah NWR, S.C.	0.45	Okefenokee NWR, Ga.	0.04 B
Merritt Is. NWR, Fla.	0.41 A	Atchafalaya Basin, La.	0.012 B

Table 4 (continued)

DDE		PCB's	
Site	Geometric[a] mean	Site	Geometric[a] mean
	Little blue heron (continued)		
Sabine NWR, La.	0.32	Missouri	0.0 B
Salvador, La.	0.32 A	St. Marks NWR, Fla.	0.0 B
Tampa Bay, Fla.	0.21	Salvador, La.	0.0 B
J.N. "Ding" Darling NWR, Fla.	0.14 A	J.N. "Ding" Darling NWR, Fla.	0.0 B
Lacassine NWR, La.	0.11 A	Lacassine NWR, La.	0.0 B
	Cattle egret		
Savannah NWR, S.C.	7.0	Yazoo NWR, Miss.	0.88 A
Yazoo NWR, Miss.	4.3 A	Savannah NWR, S.C.	0.70
Santee NWR, S.C.	1.9 AB	Merritt Is. NWR, Fla.	0.53 A
Potomac River, Md.	1.2 AB	Blackbeard Is. NWR, Ga.	0.25
Merritt Is. NWR, Fla.	0.93 AB	Potomac River, Md.	0.24 A
Orange Lake, Fla.	0.66 AB	Santee NWR, S.C.	0.19 A
Stapleton, Ala.	0.60	Okefenokee NWR, Ga.	0.14 A
Lake Istokpoga, Fla.	0.58 AB	Orange Lake, Fla.	0.12 A
Tampa Bay, Fla.	0.53	Sabine NWR, La.	0.0
Sarasota Bay, Fla.	0.38	Salvador, La.	0.0
Okefenokee NWR, Ga.	0.38 AB	Stapleton, Ala.	0.0
Blackbeard Is. NWR, Ga.	0.38	St. Marks NWR, Fla.	0.0
Salvador, La.	0.27 B	Tampa Bay, Fla.	0.0
St. Marks NWR, Fla.	0.24	Sarasota Bay, Fla.	0.0 A
Sabine NWR, La.	0.10	Lake Istokpoga, Fla.	0.0 A
	Great egret		
New Jersey	4.2 A	Long Island, N.Y.	8.6
Pea Is. NWR, N.C.	3.8	Detroit River, Mich.	6.4
Long Island, N.Y.	2.8	New Jersey	4.0 A
Chincoteague Bay, Md.-Va.	2.4 AB	Pelican Lake, Minn.	2.9 AB
Okefenokee NWR, Ga.	2.3	Pea Is. NWR, N.C.	1.6
Cape Romain NWR, S.C.	2.2 AB	Merritt Is. NWR, Fla.	1.5 ABC
Atchafalaya Basin, La.	2.1 AB	Chincoteague Bay, Md.-Va.	1.3 ABC
Blackbeard Is. NWR, Ga.	2.1	Atchafalaya Basin, La.	0.97 ABC
Pelican Lake, Minn.	2.0 AB	Cape Romain NWR, S.C.	0.83 ABC
Detroit River, Mich.	1.9	Drum Island, S.C.	0.77
Wassaw NWR, Ga.	1.4	J.N. "Ding" Darling NWR, Fla.	0.65 BC
Cedar Keys NWR, Fla.	1.0	Sarasota Bay, Fla.	0.54
J.N. "Ding" Darling NWR, Fla.	0.98 B	Barataria Bay, La.	0.43
Sabine NWR, La.	0.78 B	Sabine NWR, La.	0.30 C
Merritt Is. NWR, Fla.	0.66 B	Wassaw NWR, Ga.	0.25
Barataria Bay, La.	0.49	Blackbeard Is. NWR, Ga.	0.16
Chassahowitzka NWR, Fla.	0.42 B	Chassahowitzka NWR, Fla.	0.13 C
Drum Island, S.C.	0.38	Cedar Keys NWR, Fla.	0.0
Sarasota Bay, Fla.	0.28	Okefenokee NWR, Ga.	0.0
	Snowy egret		
Gardiner's Island, N.Y.	11.0	Long Island, N.Y.	7.9 A
House Island, Mass.	3.1 A	House Island, Mass.	6.1 AB
Gould Island, R.I.	2.8 A	Gardiner's Island, N.Y.	4.2
Long Island, N.Y.	2.0 A	Gould Island, R.I.	3.0 ABC
Chincoteague Bay, Md.-Va.	2.0 A	New Jersey	2.3 ABC
St. Marks NWR, Fla.	1.9 A	St. Marks NWR, Fla.	1.9 ABC
Atchafalaya Basin, La.	1.9	Chincoteague Bay, Md.-Va.	1.7 ABC
New Jersey	1.8 A	Martha's Vineyard, Mass.	1.6
Cat Island, Ala.	1.2 A	Cat Island, Ala.	1.5 ABC
Pea Is. NWR, N.C.	1.0 A	Sarasota Bay, Fla.	1.5

Table 4 (continued)

DDE		PCB's	
Site	Geometric[a] mean	Site	Geometric[a] mean
	Snowy egret (continued)		
Lake Boeuf, La.	1.0 A	Atchafalaya Basin, La.	1.2
Lake Istokpoga, Fla.	0.96 A	Okefenokee NWR, Ga.	0.81
Blackbeard Is. NWR, Ga.	0.80 A	Lake Boeuf, La.	0.67 BC
Cape Romain NWR, S.C.	0.79 A	Cape Romain NWR, S.C.	0.57 BC
Okefenokee NWR, Ga.	0.74	Merritt Is. NWR, Fla.	0.53 BC
Sarasota Bay, Fla.	0.64	Sabine NWR, La.	0.51 BC
J.N. "Ding" Darling NWR, Fla.	0.59 A	Barataria Bay, La.	0.46
Sabine NWR, La.	0.57 A	Lake Istokpoga, Fla.	0.46 BC
Merritt Is. NWR, Fla.	0.54 A	Salvador, La.	0.43 BC
Martha's Vineyard, Mass.	0.53	Pea Is. NWR, N.C.	0.29 BC
Cedar Keys NWR, Fla.	0.37 A	J.N. "Ding" Darling NWR, Fla.	0.29 BC
Salvador, La.	0.26 A	Cedar Keys NWR, Fla.	0.24 C
Barataria Bay, La.	0.25	Blackbeard Is. NWR, Ga.	0.21 C
Wassaw NWR, Ga.	0.25	Wassaw NWR, Ga.	0.0
Everglades NP, Fla.	0.19	Everglades NP, Fla.	0.0
	Louisiana heron		
St. Marks NWR, Fla.	1.3 A	Sarasota Bay, Fla.	2.0
Atchafalaya Basin, La.	1.2 A	St. Marks NWR, Fla.	1.4 A
Sarasota Bay, Fla.	1.1	Barataria Bay, La.	1.4 A
New Jersey	1.1	Cat Island, Ala.	1.3 A
Cat Island, Ala.	0.98 A	New Jersey	1.3
Chincoteague Bay, Md.-Va.	0.88 A	Atchafalaya Basin, La.	1.2 A
Lake Boeuf, La.	0.68 A	Salvador, La.	1.1 A
Blackbeard Is. NWR, Ga.	0.68 A	Tampa Bay, Fla.	1.0
Pea Is. NWR, N.C.	0.60 A	Chincoteague Bay, Md.-Va.	0.97 A
Lacassine NWR, La.	0.60	Merritt Is. NWR, Fla.	0.81 A
Sabine NWR, La.	0.55 A	Wassaw NWR, Ga.	0.51
Savannah NWR, S.C.	0.54	Savannah NWR, S.C.	0.50
Salvador, La.	0.50 A	Sabine NWR, La.	0.49 A
Lake Istokpoga, Fla.	0.50 A	Lake Boeuf, La.	0.32 A
Merritt Is. NWR, Fla.	0.49 A	Lacassine NWR, La.	0.31 A
Barataria Bay, La.	0.42 A	Blackbeard Is. NWR, Ga.	0.28 A
J.N. "Ding" Darling NWR, Fla.	0.41 A	Pea Is. NWR, N.C.	0.21 A
Tampa Bay, Fla.	0.38	Chassahowitzka NWR, Fla.	0.20 A
Cape Romain NWR, S.C.	0.36 A	Lake Istokpoga, Fla.	0.19 A
Wassaw NWR, Ga.	0.33	Cape Romain NWR, S.C.	0.17 A
Cedar Keys NWR, Fla.	0.21	J.N. "Ding" Darling NWR, Fla.	0.13 A
Everglades NP, Fla.	0.16 A	Cedar Keys NWR, Fla.	0.12
Chassahowitzka NWR, Fla.	0.15 A	Everglades NP, Fla.	0.0 A
	Black-crowned night heron		
Long Island, N.Y.	7.0 A	Middle Brewster Island, Mass.	22.0 A
Middle Brewster Island, Mass.	5.8 AB	House Island, Mass.	12.0 AB
Gardiner's Island, N.Y.	5.3 ABC	Gould Island, R.I.	10.0 AB
House Island, Mass.	4.5 ABCD	Detroit River, Mich.	9.9 ABC
Clark's Island, Mass.	4.5 ABCD	Long Island, N.Y.	8.4 ABC
Gould Island, R.I.	4.5 ABCD	Clark's Island, Mass.	7.3 ABCD
Detroit River, Mich.	3.8 ABCD	Martha's Vineyard, Mass.	6.0 ABCD
New Jersey	3.6 ABCD	New Jersey	4.3 BCDE
Martha's Vineyard, Mass.	2.7 ABCD	Gardiner's Island, N.Y.	3.4 BCDE
Chincoteague Bay, Md.-Va.	2.4 ABCD	Ohio	3.1
Ohio	1.6	Chincoteague Bay, Md.-Va.	1.8 CDE
Drum Island, S.C.	1.5 ABCD	Merritt Is. NWR, Fla.	1.8 CDE
St. Marks NWR, Fla.	1.5 BCD	Blackbeard Is. NWR, Ga.	1.1 CDE

Table 4 (continued)

DDE		PCB's	
Site	Geometric[a] mean	Site	Geometric[a] mean
	Black-crowned night heron (continued)		
Pea Is. NWR, N.C.	1.3 BCD	Pea Is. NWR, N.C.	0.73 DE
Merritt Is. NWR, Fla.	1.0 BCD	Drum Island, S.C.	0.71 E
Blackbeard Is. NWR, Ga.	0.95 BCD	St. Marks NWR, Fla.	0.68 E
Sabine NWR, La.	0.89 CD	Sabine NWR, La.	0.46 E
Lake Johanna & Pelican Lake, Minn.	0.85 CD	Lake Johanna & Pelican Lake, Minn.	0.35 E
Lacassine NWR, La.	0.69 D	Lacassine NWR, La.	0.25 E
Atchafalaya Basin, La.	0.35	Atchafalaya Basin, La.	0.20
J.N. "Ding" Darling NWR, Fla.	0.33 D	J.N. "Ding" Darling NWR, Fla.	0.20 E
Chassahowitzka NWR, Fla.	0.31 D	Chassahowitzka NWR, Fla.	0.14 E
	Yellow-crowned night heron		
Drum Island, S.C.	1.5	Drum Island, S.C.	0.0
Atchafalaya Basin, La.	0.88 A	Atchafalaya Basin, La.	0.0 A
Blountstown, Fla.	0.35 A	Blountstown, Fla.	0.0 A
Wassaw NWR, Ga.	0.31	Wassaw NWR, Ga.	0.0
Lacassine NWR, La.	0.18 A	Lacassine NWR, La.	0.0 A
St. Marks NWR, Fla.	0.0	St. Marks NWR, Fla.	0.0
	Least bittern		
St. Marks NWR, Fla.	1.1	St. Marks NWR, Fla.	0.48
Lake Okeechobee, Fla.	1.0 A	Merritt Is. NWR, Fla.	0.17 A
Payne's Prairie, Fla.	0.67	Sabine NWR, La.	0.0 A
Sabine NWR, La.	0.35 B	Lake Okeechobee, Fla.	0.0 A
Merritt Is. NWR, Fla.	0.29 B	Payne's Prairie, Fla.	0.0
	Glossy ibis		
Chincoteague Bay, Md.-Va.	2.0 A	Long Island, N.Y.	0.59 A
Pea Is. NWR, N.C.	1.8 A	New Jersey	0.29 A
Long Island, N.Y.	1.8 A	Chincoteague Bay, Md.-Va.	0.16 A
Cape Romain NWR, S.C.	1.5 A	Gardiner's Island, N.Y.	0.11
New Jersey	1.5 A	Pea Is. NWR, N.C.	0.032 A
Gardiner's Island, N.Y.	0.96	Cape Romain NWR, S.C.	0.0 A
Merritt Is. NWR, Fla.	0.34 A	Merritt Is. NWR, Fla.	0.0 A
Barataria Bay, La.	0.23	Barataria Bay, La.	0.0
	White-faced ibis		
Sabine NWR, La.	0.35	Sabine NWR, La.	0.0
Barataria Bay, La.	0.27	Barataria Bay, La.	0.0
	White ibis		
Tampa Bay, Fla.	0.67	Tampa Bay, Fla.	0.25
Sarasota Bay, Fla.	0.29	Merritt Is. NWR, Fla.	0.21 A
Barataria Bay, La.	0.28 A	Barataria Bay, La.	0.12 A
Merritt Is. NWR, Fla.	0.27 A	Cedar Keys NWR, Fla.	0.12 A
Lake Istokpoga, Fla.	0.14 A	Sarasota Bay, Fla.	0.0
Cedar Keys NWR, Fla.	0.12 A	Lake Istokpoga, Fla.	0.0 A
J.N. "Ding" Darling NWR, Fla.	0.11	J.N. "Ding" Darling NWR, Fla.	0.0
Everglades NP, Fla.	0.08 A	Everglades NP, Fla.	0.0 A
	Roseate spoonbill		
Sabine NWR, La.	0.76	Sabine NWR, La.	0.19
Everglades NP, Fla.	0.42	Everglades NP, Fla.	0.12

[a]Although all site means are listed in this table for visual comparison (if eggs for that species were collected from more than one locality), statistical comparisons included only those sites with at least five samples for that species, and these means are followed by letters A-E in the table. For each species, site means that do not share the same letters are significantly different ($P < 0.05$) from each other (DDE and PCB's considered separately). Means of 0.0 ppm reflect that DDE or PCB's were not detected in certain collection sites for that species, or that the mean was less than 0.01 ppm.

Table 5. *Mean DDE and PCB residue concentrations (ppm, wet weight) in eggs of anhingas and wading birds, 1972–73, ranked by species within regions.*

DDE		PCB's	
Species	Geometric[a] mean	Species	Geometric[a] mean
		Great Lakes Region	
Great blue heron	6.76 A	Great blue heron	13.65 A
Black-crowned night heron	2.96 A	Black-crowned night heron	7.10 A
		Northern Atlantic Region	
Black-crowned night heron	4.75 A	Black-crowned night heron	8.73 A
Snowy egret	2.66 B	Snowy egret	5.00 B
Glossy ibis	1.64 B	Glossy ibis	0.50 C
		Southern Atlantic Region	
Wood stork	4.00 A	Great blue heron	2.42 A
Great blue heron	2.13 AB	Black-crowned night heron	1.77 A
Black-crowned night heron	1.86 AB	Little blue heron	1.37 A
Great egret	1.82 AB	Great egret	1.32 A
Glossy ibis	1.46 AB	Wood stork	1.19 AB
Snowy egret	1.12 AB	Anhinga	1.07 AB
Cattle egret	1.04 AB	Snowy egret	0.90 AB
Little blue heron	0.92 B	Louisiana heron	0.49 AB
Green heron	0.79 B	Cattle egret	0.37 AB
Louisiana heron	0.59 B	Green heron	0.27 AB
Anhinga	0.39 B	White ibis	0.21 AB
Least bittern	0.29 B	Least bittern	0.17 AB
White ibis	0.27 B	Glossy ibis	0.14 B
		Inland Region	
Great blue heron	3.90 A	Great blue heron	2.95 A
Great egret	2.06 AB	Great egret	1.44 AB
Anhinga	1.61 ABC	Louisiana heron	0.70 BC
Least bittern	0.96 ABC	Snowy egret	0.60 BC
Cattle egret	0.88 BC	Anhinga	0.32 BC
Little blue heron	0.82 BC	Black-crowned night heron	0.31 BC
Snowy egret	0.80 BC	Little blue heron	0.28 C
Louisiana heron	0.73 BC	Green heron	0.15 C
Black-crowned night heron	0.71 BC	Cattle egret	0.14 C
Green heron	0.70 BC	White ibis	0.0 C
Yellow-crowned night heron	0.59 BC	Least bittern	0.0 C
White ibis	0.14 C	Yellow-crowned night heron	0.0 C
		Gulf Coast Region	
Great blue heron	1.39 A	Great blue heron	1.70 A
Black-crowned night heron	0.82 AB	Snowy egret	0.78 AB
Snowy egret	0.80 AB	Louisiana heron	0.61 AB
Great egret	0.74 AB	Black-crowned night heron	0.39 B
Roseate spoonbill	0.69 AB	Great egret	0.35 B
Louisiana heron	0.56 AB	Roseate spoonbill	0.18 B
Anhinga	0.50 AB	Anhinga	0.15 B
Least bittern	0.46 AB	Little blue heron	0.14 B
Green heron	0.42 AB	White ibis	0.08 B
Cattle egret	0.35 AB	Least bittern	0.07 B
Little blue heron	0.34 AB	Green heron	0.07 B
White-faced ibis	0.32 AB	White-faced ibis	0.0 B
White ibis	0.19 B	Yellow-crowned night heron	0.0 B
Yellow-crowned night heron	0.16 B	Cattle egret	0.0 B

[a]For each region, species means that do not share the same letters are significantly different ($P < 0.05$) from each other (DDE and PCB's considered separately). Means of 0.0 ppm reflect that PCB's were not detected in certain species from that region.

but in Southern Atlantic and Gulf Coast samples, DDT and *cis*-chlordane were considerably less frequent in this species than in others (Table 2 and Appendix II-C). DDD and PCB's were less frequently detected in little blue heron eggs from the Gulf Coast, and PCB's also in samples from Inland localities, than the average for all species combined.

Residues of DDE, DDD, *cis*-chlordane, and PCB's occurred in cattle egret eggs less commonly than the average for all species combined, but mirex was consistently more frequent in cattle egret samples than in those of other species (Table 2 and Appendix II-D). In eggs from the Southern Atlantic, DDT and dieldrin also were more common in cattle egrets than the average for all species combined.

Almost all chemicals were consistently more common in great egret eggs than the average for all species combined, and two eggs of this species from Atchafalaya Basin, La., were the only samples with detectable residues of endrin (Table 2 and Appendix II-E).

Mirex was found in fewer snowy egret eggs than the average for all species combined (Table 2 and Appendix II-F). However, DDT and dieldrin (Inland), heptachlor epoxide and oxychlordane (Northern Atlantic), and *cis*-chlordane (Northern Atlantic and Southern Atlantic, but not Gulf Coast) also were less frequent in snowy egret samples from some regions than in eggs of other species. HCB, toxaphene, and endrin were not detected.

Residues of PCB's occurred at higher frequency in the snowy egret and Louisiana heron eggs from the Inland and Gulf Coast regions than the overall average for all samples from these two regions, but they were detected in none of the 32 yellow-crowned night heron eggs and in only 1 of 22 least bittern eggs from these regions (Table 2 and Appendices II-F, -G, -H, -J). Almost all other chemicals also were detected substantially less often in yellow-crowned night herons and least bitterns than the average for all species combined.

Frequency of DDD was low, especially in Southern Atlantic samples, and HCB and endrin were not detected in Louisiana heron eggs. Heptachlor epoxide, *cis*-chlordane, *cis*-nonachlor, HCB, toxaphene, and endrin were not detected in yellow-crowned night herons. Heptachlor epoxide, mirex, oxychlordane, *cis*-nonachlor, HCB, toxaphene, and endrin were not found in least bittern eggs.

By contrast, residues of most chemicals, but especially oxychlordane and *cis*-chlordane (in both Atlantic Coastal regions) and PCB's (in Inland and all coastal areas), occurred more frequently in black-crowned night heron eggs than the average for all species combined (Ohlendorf et al. 1978*a*). However, in the samples from the Inland region all chemicals except DDE, dieldrin, and PCB's occurred at below average frequency in the black-crowned night heron eggs, although samples for this species were few (12). Toxaphene and endrin were not detected in black-crowned night heron samples.

The only chemical detected in the single American bittern egg that we analyzed was DDE (Appendix II-K).

When glossy ibis eggs from the Southern Atlantic region were compared with eggs of other species, residues of DDD, DDT, and dieldrin occurred relatively often, but PCB's were less commonly found in the glossy ibis eggs from both Atlantic Coastal regions (Table 2 and Appendix II-L). Heptachlor epoxide, mirex, oxychlordane, *cis*-nonachlor, toxaphene, and endrin were not detected in glossy ibis eggs from any region.

The only chemicals detected in the 14 white-faced ibis eggs we analyzed were DDE and dieldrin (Appendix II-M).

In white ibis eggs, the frequency of each chemical was lower than the average for all species combined (Table 2 and Appendix II-N). In particular, DDE, DDT, dieldrin, and PCB's were substantially less common in the white ibis eggs; DDD, *cis*-chlordane, *cis*-nonachlor, HCB, toxaphene, and endrin were not detected.

In roseate spoonbill eggs DDT, DDD, and dieldrin were much more common than in most other eggs from the Gulf Coast region (Table 2 and Appendix II-O). Frequency of DDE and PCB's in spoonbill eggs was similar to that in other species. Heptachlor epoxide, mirex, oxychlordane, *cis*-nonachlor, HCB, toxaphene, and endrin were not detected.

Residue Concentration

The differences in residue concentration among species are not distinct, in part because of the differences in species composition of egg collections as well as in levels of exposure at the various localities. Mean DDE and PCB concentrations for each of the species at individual sites probably reflect reasonably well the differing levels of exposure among the species. These means for selected collection sites are compared in Appendix IV.

Significant differences ($P < 0.05$) were noted among species-mean DDE concentrations at seven sites (Cedar Keys NWR, Darling NWR, Everglades NP, and Merritt Island NWR, Fla.; Cape Romain NWR, S.C.; New Jersey; and Long Island, N.Y.). At those sites and at others where the differences were not significant, DDE residue concentrations usually were higher in eggs of the great blue heron, great egret, black-crowned night heron, and roseate spoonbill than in those of other species. DDE concentrations usually

were lower in eggs of the green heron, little blue heron, yellow-crowned night heron, least bittern, and ibis (except glossy ibis from Pea Island NWR, N.C., and Chincoteague Bay, Md.-Va.) than in those of other species. Eggs of other species were not consistently in either the high or low group, but were sometimes in one or the other.

Species-mean PCB concentrations were significantly different ($P < 0.05$) at 14 sites (Lacassine NWR, Atchafalaya Basin, Salvador, and Barataria Bay, La.; St. Marks NWR, Darling NWR, and Lake Istokpoga, Fla.; Blackbeard Island NWR, Ga.; Pea Island NWR, N.C.; Chincoteague Bay, Md.-Va.; New Jersey; Long Island, N.Y.; Rhode Island; and House Island, Mass.). PCB residue concentrations usually were higher in eggs of the great blue heron, great egret, snowy egret, Louisiana heron, and black-crowned night heron than in those of most other species, and lower in eggs of green heron, cattle egret, yellow-crowned night heron, least bittern, and ibis than in those of most other species.

Wood stork eggs were collected only at Merritt Island NWR, Fla.; they contained relatively high mean concentrations of both DDE and PCB's.

The PCB/DDE ratio was usually lower in eggs of the green heron, little blue heron, cattle egret, yellow-crowned night heron, least bittern, and ibises than in those of other species (Appendix III). The ratio was usually higher (often greater than 1.0) in eggs of the snowy egret and Louisiana heron from the Gulf Coast and Louisiana Inland sites than in those of other species from the same colonies.

Eggshell Thickness

Eggshell thinning was detected in four species: anhinga, great blue heron, black-crowned night heron, and wood stork (Appendix V). The data for black-crowned night heron have been subjected to extensive statistical analysis and discussion (Ohlendorf et al. 1978*a*). Highly significant decreases ($P < 0.001$) in mean shell thickness during recent times (compared with the pre-1947 period) were detected for black-crowned night herons in samples from New Jersey (−12.3%), Massachusetts (−9.3%), and New York, Rhode Island, and Connecticut (combined into one region, −7.1%). Significant decreases ($P < 0.01$) of 4.6% to 5.6% occurred also in recent eggs from Ohio, Michigan, Florida, Georgia, and South Carolina. Samples of eggs from North Carolina, Maryland, Virginia, and Minnesota were slightly thinner, but the differences were not statistically significant ($P > 0.05$). Changes in eggshell thickness could not be definitely related to specific organochlorine residues because of the intercorrelation of chemical concentrations, but concentrations of DDE residues were consistently correlated with eggshell thinning in various statistical tests (see Ohlendorf et al. 1978*a* for a discussion of the problems in correlating and regressing residues with shell thickness changes).

The wood stork has been experiencing a severe decline in population numbers in Florida for several years (Ogden 1978). We were able to collect wood stork eggs only at Merritt Island NWR, Fla., where the species nested with anhingas and several species of herons. Recent eggs of this species averaged 8.9% thinner than pre-1947 samples ($P < 0.001$).

A decrease in shell thickness (−7.5%; $P < 0.05$) was detected in anhinga eggs recently collected in Louisiana and Mississippi, but there was no significant change in thickness among a pooled sample of eggs from three sites in Florida. DDE has been implicated as the cause of shell thinning in correlation analyses between concentrations of residues and changes in shell thickness in both anhinga and wood stork (see Ohlendorf et al. 1978*b* for a more complete discussion of anhinga and wood stork).

Thickness measurements from recent collections of eggs of great blue herons from five localities in Florida were pooled and compared with a large sample of eggs collected in Florida and Tennessee before 1947. The difference in means (−5.2%) was significant ($P < 0.001$). Similar comparisons were made for eggs collected in midwestern States of Minnesota, Michigan, and Ohio; a significant decrease (−7.9%; $P < 0.001$) in shell thickness was also found in these samples. Although we measured thickness in a large sample of previously collected great blue heron eggs from other areas of the eastern United States, we were unable to collect comparable recent eggs. Mean thicknesses for these pre-1947 eggs from a large number of sites are given for reference (Appendix V).

Shell thickness changes were not detected in eggs of 11 other species studied, even though substantial numbers of clutches were available from many sites for both periods.

We tested eggshell thickness means for sites as grouped in Appendix V within each period, using 2-way ANOVA procedures. Significant site differences ($P < 0.05$) in both periods were detected for anhinga, great blue heron, great egret, snowy egret, Louisiana heron, black-crowned night heron, least bittern, and glossy ibis. However, interactions were significant only for the anhinga, great blue heron, and black-crowned night heron, species in which differences were detected over time. Site differences were not detected in the green heron, little blue heron, white ibis, or roseate spoonbill. Thus, the "site effect" is consistent over time for all species except the three in which a "time effect" occurred. Presumably, this time effect on eggshell thickness is related to the introduction of

DDT to the environment and its occurrence at elevated levels in eggs of these species at certain sites.

For a few species in which sample sizes were sufficient, we also tested for differences in shell thickness relative to other factors. Significant differences ($P < 0.05$) were found between complete and incomplete clutches in recent eggs of the black-crowned night heron, but incomplete clutches were thinner than complete clutches at some sites and thicker at others (Ohlendorf et al. 1978*a*). Thicknesses of complete clutches were not significantly different ($P > 0.05$) from incomplete clutches in the anhinga, great blue heron, or great egret in either period. No significant differences were detected between clutch means grouped according to stages of incubation (fresh, slight, moderate, or advanced) in the Louisiana heron or black-crowned night heron in either period.

Conspicuous gaps occur in the data in Appendix V for certain species and collection sites in one or the other of the two periods. For instance, we were unable to find pre-1947 eggs of the cattle egret in museums because the species did not breed in the United States before the 1950's (Peterson 1954). The snowy egret, little blue heron, Louisiana heron, and glossy ibis have expanded their breeding ranges northward within the last 30-40 years (Palmer 1962). Thus, we were able to collect samples of recent eggs for these species from localities where they did not formerly breed. Wherever gaps occur in the data for recent eggs, it is usually because of our inability to be in an area when the species was breeding (e.g., great blue heron) or because of the relative difficulty in locating nests of species that tend to nest solitarily rather than in colonies (e.g., green heron, least bittern).

Additional information on residues and shell thickness in recent eggs is needed for the great blue heron in all eastern coastal States from Georgia to Maine, for the green heron in the North Atlantic region and all midwestern States, for the least bittern in all States except Florida, and for the great white heron in the Florida Keys.

Discussion and Conclusions

Interpretation of differences in the geographic distribution of persistent pollutants in the environment is difficult. We do not know usage patterns of the various chemicals, but they probably vary widely among geographic areas and with time. Species and individual differences in feeding habitats, biologic magnification in higher trophic levels, and migration of individual birds to different localities may further complicate interpretation.

In spite of the variation in residue concentrations among eggs of the same species from the same collection site, we were able to detect statistically significant regional and local differences in the occurrence of organochlorine residues in certain species. Likewise, we found differences in organochlorine residue concentrations among different species nesting at the same site.

Significant geographic and species differences were more easily detected when we deleted from the comparisons those species or sites from which we had fewer than five samples. We found that 10 eggs (one from each of 10 clutches) per species at each site were generally adequate and that 5 eggs per species still could be used in comparing sites and species, but when we had fewer than 5 eggs, the amount of variation in residue concentrations was usually too great for us to detect statistically significant differences. However, some samples (great blue heron from Shiawassee NWR, Mich., for example) that were excluded from the statistical comparisons contained high concentrations of organochlorine residues that probably were affecting the birds. Consequently, we included all samples in the tables to enable visual comparisons of the data.

We were especially concerned about the impact of environmental pollutants on black-crowned night herons, because drastic population declines of this species had been reported in southern New England and in Michigan (see Ohlendorf 1978*a* for review). By analyzing band recovery (encounter) data for this species and other data, we concluded that most of the differences in residues found in the night heron eggs resulted from differences in exposure while in the breeding areas. The same principle seems to apply to other species, but there is no doubt that birds also acquire organochlorine residues in migration and at winter feeding grounds. For example, herons that nested in Minnesota and Wisconsin may have been exposed to mirex and heptachlor epoxide in areas farther south, where mirex and heptachlor were used for attempted control of the imported fire ant (*Solenopsis invicta*).

Field and experimental evidence indicates that declines in eggshell thickness observed in certain species in North America and Great Britain since the mid-1940's have been largely caused by residues of DDE or other compounds or metabolites of the DDT group (Cooke 1973; L. F. Stickel 1973; W. H. Stickel 1975; Ohlendorf et al. 1978*a*, 1978*d*). At moderate or high levels of DDE, shell thinning is severe and eggs may break during incubation. High DDE levels have been recorded in California; species affected there have included brown pelicans (Risebrough et al. 1971), double-crested cormorants (Gress et al. 1973), great egrets, and great blue herons (Faber et al. 1972). Much of the DDE probably originated from an insecticide manufacturing plant in southern California.

Eggshell thinning has occurred in several other

species that occupy freshwater or estuarine habitats or that nest on coastal islands. In 1967, shell thickness in eggs of herring gull (*Larus argentatus*) from five States decreased with increases in chlorinated hydrocarbon residues (Hickey and Anderson 1968). Comparison of eggshells taken before 1946 with those taken since then reveals that several species, including the peregrine falcon (*Falco peregrinus*), brown pelican, double-crested cormorant, black-crowned night heron, bald eagle (*Haliaeetus leucocephalus*), and osprey (*Pandion haliaetus*), have sustained shell-thickness and shell-weight decreases of 20% or more, at least for brief periods (Anderson and Hickey 1972). In some of these, regional population declines are known.

Shell thickness was significantly and inversely correlated with the concentration of DDE in 40 great blue heron eggs from Alberta (Vermeer and Reynolds 1970; Vermeer and Risebrough 1972).

In the upper Great Lakes States, 9 of 13 species of fish-eating birds were found in 1969-70 to have sustained statistically significant decreases in eggshell thickness since 1946 (Faber and Hickey 1973). Maximum changes in a thickness index occurred in great blue herons (−25%), red-breasted mergansers (*Mergus serrator;* −15%), and double-crested cormorants (−15%). Heron eggs taken in Louisiana generally displayed a smaller post-1946 change than herons in the Middle West. Although DDE was a prominent factor for most groups, especially herons, in relation to the eggshell thinning observed, dieldrin and PCB's also were associated with thinning in some species. This relationship, however, may have been due to correlation in concentrations of these chemicals and concentrations of DDE.

The thinning of eggshells of the brown pelican has proven to be related to the concentrations of DDE in the eggs (Blus et al. 1971; Blus et al. 1972*a*, 1972*b*). Nearly all brown pelican eggs collected from 13 colonies in South Carolina, Florida, and California in 1969 and from 17 colonies in South Carolina and Florida in 1970 exhibited eggshell thinning (Blus 1970; Blus et al. 1974*a*). Of the 100 eggs analyzed for residues of pollutants, all contained measurable quantities of DDE; most eggs contained measurable quantities of DDD, DDT, dieldrin, or PCB's. DDE appears to have been responsible for virtually all the eggshell thinning.

Nest success of brown pelicans in South Carolina was related to residues of DDE and dieldrin in sample eggs (Blus et al. 1974*b*). Residues of DDE seemed primarily responsible for nest failure; however, deleterious effects of this pollutant on nest success were not satisfactorily separated from those induced by dieldrin. Significant intercorrelation of all five organochlorine residues identified in the eggs complicated evaluation of the relationship of residues to nest success. Maximum DDE residues in an egg from a successful nest were 2.4 ppm and in an egg from an unsuccessful nest, 8.5 ppm. Comparable maximum residues for dieldrin in sample eggs were 0.54 ppm (successful) and 0.99 ppm (unsuccessful). Residues of DDD, DDT, or PCB's in sample eggs were not significantly related to nest success. Reproductive success in the brown pelican colony was subnormal in the 2 years of study (1971-72), but reproductive success was normal in those nests in which the sample egg contained either 2.5 ppm or less of DDE or 0.54 ppm or less of dieldrin.

Residues of DDE, DDD, DDT, dieldrin, and PCB's exhibited a significant decline in South Carolina brown pelican eggs from 1969 through 1973 (Blus et al. 1977), but the decrease in DDD was greatest. In 1973, the pelicans experienced excellent reproductive success for the first time in many years, and the decline in residues was related to this improvement. DDE was implicated as the agent responsible for most pollutant-induced nest failure; residues greater than 3.7 ppm in the sample egg were associated with total failure of those eggs remaining in the nest. The improvement in reproductive success was not associated with an increase in average eggshell thickness.

Reproductive success of a colony of great egrets in California declined between 1967 and 1970 (Pratt 1970; Faber et al. 1972). Successful nesting attempts decreased progressively from 52% to 28%, and nests losing eggs increased from 30% to 54%. Reproductive success of this colony's great blue herons showed no comparable trends over this period, but there was significant eggshell thinning (when compared with pre-1947 samples) in both species. Although no eggs were analyzed for dieldrin and endrin, levels of these chemicals (5 to 7 ppm dieldrin; 0.10 to 0.28 ppm endrin) in the brains of four adult egrets found dead or moribund suggest death by organochlorine poisoning. DDE and PCB residue levels in the four eggs analyzed were lower than the levels found in some of the eggs we analyzed, but comparisons based on so few samples may not be valid.

The most comprehensive studies of the effects of environmental pollutants on a heron species have been made on the gray heron (*Ardea cinerea*) in Great Britain (Milstein et al. 1970; Prestt 1970; Cooke et al. 1976). Of particular interest are the observations of high incidences of deliberate egg destruction by brooding herons, seemingly induced by organochlorines. On a heronry basis, the proportion of pairs breaking their eggs was linearly related to mean residues of DDE and dieldrin in surviving eggs. Although more than half the pairs broke their eggs during some years, heron populations have not declined overall, perhaps because of the ability of this species to lay repeat clutches. DDE and PCB residue

levels in the gray heron eggs are similar to those in some of our heron colonies, but dieldrin levels are considerably higher than in the eggs we analyzed.

We cannot positively relate the organochlorine residues we found in eggs to the population declines of any species that have been reported, but circumstantial evidence suggests these chemicals may contribute to impaired reproduction in the more contaminated areas.

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Appendix I

Chemical names of compounds discussed in this article.

Cis-chlordane	1-exo,2-exo,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene
Cis-nonachlor	1-exo,2-exo,3-exo,4,5,6,7,8,8-nonachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene
DDD	1,1-dichloro-2,2-bis(p-chlorophenyl)ethane
DDE	1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene
DDT	1,1-1-trichloro-2,2-bis(p-chlorophenyl)ethane
Dieldrin	1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-exo-5,8-dimethanonaphtalene
Endrin	1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-endo-5,8-dimethanonaphthalene
HCB	hexachlorobenzene
Heptachlor epoxide	1,4,5,6,7,8,8-heptachloro-2,3-epoxy-3a,4,7,7a-tetrahydro-4,7-methanoindane
Mirex	dodecachlorooctahydro-1,3,4-metheno-1H-cyclobuta (cd)pentalene
Oxychlordane	1-exo,2-endo,4,5,6,7,8,8-octachloro-2,3-epoxy-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene
PCB (polychlorinated biphenyls)	Mixtures of chlorinated biphenyl compounds having various percentages of chlorination
Toxaphene	Chlorinated camphene (content of combined chlorine, 67-69%)
Trans-nonachlor	1-exo,2-endo,3-exo,4,5,6,7,8,8-nonachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene

Appendix II

Frequencies of organochlorine residues in eggs of wading birds by species, 1972-73. (For frequencies in anhinga, black-crowned night heron, and wood stork eggs, see Ohlendorf et al. 1978a, 1978b). The following notes apply to all species, as appropriate:

1. Northern Atlantic colonies were coastal locations from New York to Massachusetts.
2. Southern Atlantic colonies were coastal locations from Florida to New Jersey.
3. *Cis*-chlordane was not separable from *trans*-nonachlor.
4. Frequency index was computed as $\frac{\text{Total occurrences}}{\text{Possible occurrences}}$.

   Total occurrences = Number of times any of the 13 organochlorines were present in eggs from that region. Possible occurrences = number of clutches from that region x 13 chemicals.
5. Chemicals not listed for a particular species were not detected in any eggs of that species.
6. Regions are given in the same sequence as in Table 2, but when no eggs of a particular species were collected from a region that region is omitted from this Appendix.

Appendix II-A. Great blue heron.

Compound	Great Lakes (_N_=13)	Southern Atlantic (_N_=10)	Inland (_N_=22)	Gulf Coast (_N_=13)	Total (_N_=58)
	Number (percent) with residues				
DDE	13 (100)	10 (100)	22 (100)	13 (100)	58 (100)
DDD	12 (92.3)	3 (30)	4 (18.2)	0	19 (32.8)
DDT	6 (46.2)	2 (20)	2 (9.1)	0	10 (17.2)
Dieldrin	13 (100)	1 (10)	16 (72.7)	2 (15.4)	32 (55.2)
Heptachlor epoxide	4 (30.8)	0	3 (13.6)	1 (7.7)	8 (13.8)
Mirex	4 (30.8)	4 (40)	5 (22.7)	2 (15.4)	15 (25.9)
Oxychlordane	5 (38.5)	2 (20)	4 (18.2)	0	11 (19.0)
Cis-chlordane	12 (92.3)	3 (30)	11 (50.0)	9 (69.2)	35 (60.3)
Cis-nonachlor	3 (23.1)	1 (10)	2 (9.1)	1 (7.7)	7 (12.1)
HCB	8 (61.5)	0	6 (27.3)	0	14 (24.1)
Toxaphene	3 (23.1)	2 (20)	4 (18.2)	0	9 (15.5)
PCB's	13 (100)	7 (70)	21 (95.5)	12 (92.3)	53 (91.4)
Total occurrences	96	35	100	40	271
Frequency index	0.568	0.269	0.350	0.237	0.359

Appendix II-B. Green heron.

Compound	Number (percent) with residues			
	Southern Atlantic (N=29)	Inland (N=34)	Gulf Coast (N=26)	Total (N=89)
DDE	28	33 (97.1)	25 (96.2)	86 (96.6)
DDD	0	1 (2.9)	0	1 (1.1)
DDT	1 (3.4)	4 (11.8)	1 (3.8)	6 (6.7)
Dieldrin	6 (20.7)	1 (2.9)	2 (7.7)	9 (10.1)
Mirex	7 (24.1)	0	0	7 (7.9)
Oxychlordane	0	1 (2.9)	0	1 (1.1)
Cis-chlordane	0	1 (2.9)	0	1 (1.1)
Cis-nonachlor	0	1 (2.9)	0	1 (1.1)
PCB's	12 (41.4)	12 (35.3)	1 (3.8)	25 (28.1)
Total occurrences	54	54	29	137
Frequency index	0.143	0.122	0.086	0.118

Appendix II-C. Little blue heron.

Compound	Number (percent) with residues				
	Northern Atlantic (N=1)	Southern Atlantic (N=39)	Inland (N=66)	Gulf Coast (N=32)	Total (N=138)
DDE	1 (100)	39 (100)	59 (89.4)	28 (87.5)	127 (92.0)
DDD	0	3 (7.7)	5 (7.6)	0	8 (5.8)
DDT	1 (100)	5 (12.8)	17 (25.8)	0	23 (16.7)
Dieldrin	0	12 (30.8)	23 (34.8)	6 (18.8)	41 (29.7)
Heptachlor epoxide	0	1 (2.6)	2 (3.0)	0	3 (2.2)
Mirex	0	3 (7.7)	5 (7.6)	1 (3.1)	9 (6.5)
Oxychlordane	0	1 (2.6)	4 (6.1)	7 (21.9)	12 (8.7)
Cis-chlordane	0	2 (5.1)	3 (4.5)	1 (3.1)	6 (4.3)
Cis-nonachlor	0	0	2 (3.0)	0	2 (1.4)
HCB	0	0	2 (3.0)	0	2 (1.4)
Toxaphene	0	0	3 (4.5)	0	3 (2.2)
PCB's	1 (100)	33 (84.6)	16 (24.2)	3 (9.4)	53 (38.4)
Total occurrences	3	99	141	46	289
Frequency index	0.231	0.195	0.164	0.111	0.161

Appendix II-D. Cattle egret.

Compound	Number (percent) with residues			
	Southern Atlantic (N=25)	Inland (N=60)	Gulf Coast (N=10)	Total (N=95)
DDE	23 (92.0)	51 (85.0)	9 (90.0)	83 (87.4)
DDD	0	4 (6.7)	0	4 (4.2)
DDT	8 (32.0)	14 (23.3)	1 (10.0)	23 (24.2)
Dieldrin	10 (40.0)	19 (31.7)	3 (30.0)	32 (33.7)
Heptachlor epoxide	1 (4.0)	3 (5.0)	1 (10.0)	5 (5.3)
Mirex	5 (20.0)	20 (33.3)	6 (60.0)	31 (32.6)
Oxychlordane	2 (8.0)	5 (8.3)	2 (20.0)	9 (9.5)
Cis-chlordane	2 (8.0)	2 (3.3)	2 (20.0)	6 (6.3)
Cis-nonachlor	0	2 (3.3)	1 (10.0)	3 (3.2)
HCB	0	1 (1.7)	0	1 (1.1)
Toxaphene	0	3 (5.0)	0	3 (3.2)
PCB's	19 (76.0)	16 (26.7)	0	35 (36.8)
Total occurrences	70	140	25	235
Frequency index	0.215	0.179	0.192	0.190

Appendix II-E. Great egret.

Compound	Great Lakes (N=2)	Northern Atlantic (N=4)	Southern Atlantic (N=44)	Inland (N=22)	Gulf Coast (N=39)	Total (N=111)
	Number (percent) with residues					
DDE	2 (100)	4 (100)	44 (100)	22 (100)	39 (100)	111 (100)
DDD	2 (100)	4 (100)	7 (15.9)	11 (50.0)	4 (10.3)	28 (25.2)
DDT	1 (50.0)	2 (50.0)	15 (34.1)	16 (72.7)	6 (15.4)	40 (36.0)
Dieldrin	2 (100)	4 (100)	18 (40.9)	15 (68.2)	10 (25.6)	49 (44.1)
Heptachlor epoxide	0	0	0	4 (18.2)	2 (5.1)	6 (5.4)
Mirex	1 (50.0)	0	10 (22.7)	3 (13.6)	2 (5.1)	16 (14.4)
Oxychlordane	0	3 (75.0)	2 (4.5)	1 (4.5)	3 (7.7)	9 (8.1)
Cis-chlordane	2 (100)	4 (100)	8 (18.2)	6 (27.3)	5 (12.8)	25 (22.5)
Cis-nonachlor	0	1 (25.0)	0	1 (4.5)	1 (2.6)	3 (2.7)
HCB	0	0	0	1 (4.5)	0	1 (0.9)
Toxaphene	1 (50.0)	0	0	5 (22.7)	0	6 (5.4)
Endrin	0	0	0	2 (9.1)	0	2 (1.8)
PCB's	2 (100)	4 (100)	41 (93.2)	19 (86.4)	21 (53.8)	87 (78.4)
Total occurrences	13	26	145	106	93	383
Frequency index	0.500	0.500	0.253	0.371	0.183	0.265

Appendix II-F. Snowy egret.

Compound	Northern Atlantic (N=39)	Southern Atlantic (N=53)	Inland (N=25)	Gulf Coast (N=53)	Total (N=170)
	Number (percent) with residues				
DDE	39 (100)	53 (100)	25 (100)	53 (100)	170 (100)
DDD	18 (46.2)	5 (9.4)	2 (8.0)	4 (7.5)	29 (17.1)
DDT	19 (48.7)	8 (15.1)	2 (8.0)	5 (9.4)	34 (20.0)
Dieldrin	29 (74.4)	18 (34.0)	3 (12.0)	11 (20.8)	61 (35.9)
Heptachlor epoxide	0	0	1 (4.0)	2 (3.8)	3 (1.8)
Mirex	0	2 (3.8)	0	2 (3.8)	4 (2.4)
Oxychlordane	7 (17.9)	1 (1.9)	1 (4.0)	5 (9.4)	14 (8.2)
Cis-chlordane	12 (30.8)	2 (3.8)	1 (4.0)	8 (15.1)	23 (13.5)
Cis-nonachlor	0	1 (1.9)	0	0	1 (0.6)
PCB's	36 (92.3)	36 (67.9)	20 (80.0)	41 (77.4)	133 (78.2)
Total occurrences	160	126	55	131	472
Frequency index	0.316	0.183	0.169	0.190	0.214

Appendix II-G. Louisiana heron.

Compound	Number (percent) with residues			
	Southern Atlantic ($\underline{N}$=44)	Inland ($\underline{N}$=33)	Gulf Coast ($\underline{N}$=76)	Total ($\underline{N}$=153)
DDE	44 (100)	33 (100)	73 (96.1)	150 (98.0)
DDD	2 (4.5)	2 (6.1)	8 (10.5)	12 (7.8)
DDT	7 (15.9)	10 (30.3)	6 (7.9)	23 (15.0)
Dieldrin	11 (25.0)	10 (30.3)	17 (22.4)	38 (24.8)
Heptachlor epoxide	0	1 (3.0)	1 (1.3)	2 (1.3)
Mirex	5 (11.4)	0	2 (2.6)	7 (4.6)
Oxychlordane	1 (2.3)	3 (9.1)	2 (2.6)	6 (3.9)
Cis-chlordane	1 (2.3)	0	4 (5.3)	5 (3.3)
Cis-nonachlor	0	0	2 (2.6)	2 (1.3)
Toxaphene	0	3 (9.1)	0	3 (2.0)
PCB's	39 (88.6)	20 (60.6)	49 (64.5)	108 (70.6)
Total occurrences	110	82	164	356
Frequency index	0.192	0.191	0.166	0.179

Appendix II-H. Yellow-crowned night heron.

	Number (percent) with residues			
Compound	Southern Atlantic (N=2)	Inland (N=20)	Gulf Coast (N=12)	Total (N=34)
DDE	2 (100)	19 (95.0)	9 (75.0)	30 (88.2)
DDD	1 (50.0)	0	0	1 (2.9)
DDT	0	2 (10.0)	0	2 (5.9)
Dieldrin	0	1 (5.0)	3 (25.0)	4 (11.8)
Mirex	2 (100)	1 (5.0)	0	3 (8.8)
Oxychlordane	1 (50.0)	0	0	1 (2.9)
PCB's	1 (50.0)	0	0	1 (2.9)
Total occurrences	7	23	12	42
Frequency index	0.269	0.088	0.077	0.095

Appendix II-J. Least bittern.

Compound	Number (percent) with residues			
	Southern Atlantic (N=8)	Inland (N=11)	Gulf Coast (N=11)	Total (N=30)
DDE	8 (100)	11 (100)	11 (100)	30 (100)
DDD	0	0	1 (9.1)	1 (3.3)
DDT	0	0	1 (9.1)	1 (3.3)
Dieldrin	0	0	2 (18.2)	2 (6.7)
Cis-chlordane	0	1 (9.1)	0	1 (3.3)
PCB's	3 (37.5)	0	1 (9.1)	4 (13.3)
Total occurrences	11	12	16	39
Frequency index	0.106	0.084	0.112	0.100

Appendix II-K. American bittern.

Compound	Number (percent) with residues	
	Inland (*N*=1)	Total (*N*=1)
DDE	1 (100)	1 (100)
Total occurrences	1	1
Frequency index	0.077	0.077

Appendix II-L. Glossy ibis.

	Number (percent) with residues			
	Northern Atlantic	Southern Atlantic	Gulf Coast	Total
Compound	(N=26)	(N=42)	(N=2)	(N=70)
DDE	26 (100)	42 (100)	2 (100)	70 (100)
DDD	13 (50.0)	7 (16.7)	0	20 (28.6)
DDT	11 (42.3)	24 (57.1)	0	35 (50.0)
Dieldrin	14 (53.8)	17 (40.5)	0	31 (44.3)
Cis-chlordane	14 (53.8)	4 (9.5)	0	18 (25.7)
HCB	1 (3.8)	0	0	1 (1.4)
PCB's	15 (57.7)	14 (33.3)	0	29 (41.4)
Total occurrences	94	108	2	204
Frequency index	0.278	0.198	0.077	0.224

Appendix II-M. White-faced ibis.

	Number (percent) with residues	
Compound	Gulf Coast (N=14)	Total (N=14)
DDE	14 (100)	14 (100)
Dieldrin	7 (50.0)	7 (50.0)
Total occurrences	21	21
Frequency index	0.115	0.115

Appendix II-N. White ibis.

Compound	Number (percent) with residues			
	Southern Atlantic (N=10)	Inland (N=11)	Gulf Coast (N=32)	Total (N=53)
DDE	9 (90.0)	7 (63.6)	27 (84.4)	43 (81.1)
DDT	1 (10.0)	1 (9.1)	2 (6.2)	4 (7.5)
Dieldrin	1 (10.0)	1 (9.1)	3 (9.4)	5 (9.4)
Heptachlor epoxide	0	0	1 (3.1)	1 (1.9)
Mirex	1 (10.0)	0	1 (3.1)	2 (3.8)
Oxychlordane	0	0	1 (3.1)	1 (1.9)
PCB's	5 (50.0)	0	8 (25.0)	13 (24.5)
Total occurrences	17	9	43	69
Frequency index	0.131	0.063	0.103	0.100

Appendix II-O. Roseate spoonbill.

Compound	Number (percent) with residues	
	Gulf Coast (N=24)	Total (N=24)
DDE	24 (100)	24 (100)
DDD	13 (54.2)	13 (54.2)
DDT	6 (25.0)	6 (25.0)
Dieldrin	10 (41.7)	10 (41.7)
Cis-chlordane	2 (8.3)	2 (8.3)
PCB's	10 (41.7)	10 (41.7)
Total occurrences	65	65
Frequency index	0.208	0.208

Appendix III

Organochlorine residue concentrations in eggs of wading birds by species, 1972-73. (For data concerning anhingas, black-crowned night herons, and wood storks, see Ohlendorf et al. 1978a, 1978b). The following notes apply to all species, as appropriate:

1. Lipid content is given as mean and standard error.
2. Cis-chlordane was not separable from trans-nonachlor.
3. ND = not detected.
4. Chemicals not listed for a particular locality were not detected in any eggs of that species from that locality.
5. An asterisk (*) in the 95% C.I. column indicates that the value calculated was biologically unrealistic (because of small sample size and high variability in those samples analyzed). In some instances the upper calculated values exceeded 1,000 ppm. For these, the range should provide a basis for comparison.

Appendix III-A. Great blue heron (N=58). Lipid content = 5.41 $\pm$ 0.12%.

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
LOUISIANA					
Sabine NWR (2)					0.3
DDE	2	3.8	*	1.6-7.7	
Cis-chlordane	1	0.059	*	ND-0.12	
PCB's	2	1.2	*	0.85-1.7	
FLORIDA					
Chassahowitzka NWR (3)					0.9
DDE	3	0.46	0-1.2	0.25-0.75	
Cis-chlordane	1	0.028	0-0.16	ND-0.087	
PCB's	2	0.43	0-2.2	ND-0.87	
J.N. "Ding" Darling NWR (8)					1.8
DDE	8	1.4	0.7-2.5	0.44-3.1	
Dieldrin	2	0.047	0-0.14	ND-0.31	
Heptachlor epoxide	1	0.10	0-0.39	ND-1.2	
Mirex	2	0.099	0-0.30	ND-0.73	
Cis-chlordane	7	0.22	0.05-0.41	ND-0.75	
Cis-nonachlor	1	0.021	0-0.08	ND-0.19	
PCB's	8	2.6	0.9-6.0	0.81-20	
Loxahatchee NWR (4)					0.1
DDE	4	12.0	3.2-41	5.4-33	
DDD	1	0.026	0-0.11	ND-0.11	
Dieldrin	2	0.094	0-0.34	ND-0.31	
Cis-chlordane	2	0.086	0-0.27	ND-0.22	
Toxaphene	2	0.054	0-0.16	ND-0.13	
PCB's	4	1.5	0.1-4.7	0.40-4.0	

Appendix III-A (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
FLORIDA (cont.)					
Merritt Island NWR (10)					1.1
DDE	10	2.1	0.6-5.1	0.28-24	
DDD	3	0.059	0-0.15	ND-0.42	
DDT	2	0.064	0-0.19	ND-0.66	
Dieldrin	1	0.028	0-0.09	ND-0.31	
Mirex	4	0.35	0-1.1	ND-5.8	
Oxychlordane	2	0.021	0-0.05	ND-0.11	
Cis-chlordane	3	0.047	0-0.11	ND-0.21	
Cis-nonachlor	1	0.009	0-0.03	ND-0.087	
Toxaphene	2	0.040	0-0.11	ND-0.30	
PCB's	7	2.4	0.8-5.5	ND-7.4	
Payne's Prairie (3)					3.0
DDE	3	2.2	0.1-8.0	1.2-4.0	
Dieldrin	3	0.36	0-2.0	0.12-0.97	
Mirex	2	0.45	0-3.8	ND-1.5	
Oxychlordane	3	0.20	0-0.70	0.087-0.41	
Cis-chlordane	3	0.49	0-2.1	0.24-1.1	
Cis-nonachlor	1	0.042	0-0.24	ND-0.13	
PCB's	3	6.5	0.4-40	2.6-13	
OHIO (9)					2.3
DDE	9	4.2	2.6-6.4	1.5-8.2	
DDD	8	0.28	0.10-0.49	ND-0.97	
DDT	3	0.076	0-0.20	ND-0.53	
Dieldrin	9	0.98	0.23-2.2	0.15-5.0	
Heptachlor epoxide	3	0.066	0-0.18	ND-0.52	
Mirex	2	0.35	0-1.1	ND-3.6	
Oxychlordane	3	0.045	0-0.10	ND-0.19	
Cis-chlordane	9	0.67	0.23-1.3	0.11-3.2	
Cis-nonachlor	2	0.023	0-0.06	ND-0.11	
HCB	4	0.057	0-0.12	ND-0.26	
Toxaphene	1	0.023	0-0.08	ND-0.24	
PCB's	9	9.6	5.1-17	ND-38	

Appendix III-A (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
MICHIGAN					
Shiawassee NWR (4)					1.6
DDE	4	18.0	0.7-220	2.1-120	
DDD	4	1.0	0-8.2	0.086-7.2	
DDT	3	1.4	0-21	ND-18.0	
Dieldrin	4	0.45	0-1.7	0.13-1.6	
Heptachlor epoxide	1	0.042	0-0.19	ND-0.18	
Mirex	2	0.48	0-2.5	ND-2.1	
Oxychlordane	2	0.11	0-0.39	ND-0.33	
Cis-chlordane	3	0.47	0-2.5	ND-2.3	
Cis-nonachlor	1	0.074	0-0.34	ND-0.33	
HCB	4	0.79	0-6.4	0.086-5.8	
Toxaphene	2	0.13	0-0.42	ND-0.33	
PCB's	4	29.0	5.3-150	6.2-65	
WISCONSIN					
Wyeville (3)					0.8
DDE	3	3.3	0.2-15	1.5-6.1	
Dieldrin	3	0.26	0.10-0.43	0.20-0.33	
Heptachlor epoxide	1	0.028	0-0.15	ND-0.084	
Mirex	1	0.37	0-4.4	ND-1.6	
PCB's	3	2.5	0.8-6.0	1.6-3.4	
MINNESOTA					
Pelican Lake & Lake Johanna (8)					0.9
DDE	8	2.2	0.8-4.8	0.24-7.7	
DDT	1	0.038	0-0.13	ND-0.34	
Dieldrin	5	0.13	0.01-0.26	ND-0.42	
Mirex	1	0.072	0-0.26	ND-0.73	
Cis-chlordane	4	0.084	0-0.17	ND-0.23	
HCB	4	0.081	0-0.24	ND-0.60	
Toxaphene	1	0.012	0-0.04	ND-0.10	
PCB's	7	1.9	0.5-4.6	ND-11	

Appendix III-A (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
MINNESOTA (cont.)					
Rice Lake (2)					0.8
DDE	2	7.0	*	4.3-11	
DDD	2	0.27	*	0.099-0.46	
Dieldrin	1	0.066	*	ND-0.14	
Mirex	1	0.35	*	ND-0.83	
HCB	1	0.045	*	ND-0.090	
PCB's	2	5.5	*	2.5-11	
IOWA (2)					1.9
DDE	2	4.2	*	2.5-6.6	
DDD	1	0.072	*	ND-0.15	
DDT	1	0.064	*	ND-0.13	
Dieldrin	2	3.3	*	1.2-7.5	
Heptachlor epoxide	2	0.36	*	0.25-0.47	
Oxychlordane	1	0.064	*	ND-0.13	
Cis-chlordane	2	0.30	*	0.22-0.38	
Cis-nonachlor	1	0.081	*	ND-0.17	
HCB	1	0.042	*	ND-0.087	
Toxaphene	1	0.14	*	ND-0.31	
PCB's	2	8.1	*	5.9-11	

Appendix III-B. Green heron ($\underline{N}$=89). Lipid content = 5.92 ± 0.17%.

Site ($\underline{N}$) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
LOUISIANA					
Sabine NWR (10)					0.2
DDE	9	0.41	0.14-0.75	ND-1.5	
DDT	1	0.028	- -	ND-0.31	
PCB's	1	0.077	0-0.27	ND-1.1	
Lacassine NWR (7)					0.0
DDE	7	0.47	0.22-0.77	0.24-1.2	
Dieldrin	2	0.062	0-0.17	ND-0.31	
Atchafalaya Basin (10)					0.5
DDE	10	1.3	0.63-2.1	0.39-5.6	
DDD	1	0.0092	0-0.03	ND-0.090	
DDT	4	0.042	0-0.08	ND-0.15	
Dieldrin	1	0.0092	0-0.03	ND-0.10	
Cis-nonachlor	1	0.016	- -	ND-0.17	
PCB's	7	0.60	0.09-1.4	ND-5.4	
Lake Boeuf (10)					0.0
DDE	10	0.49	0.31-0.71	0.18-1.1	
ALABAMA					
Stapleton (1)					0.0
DDE	1	0.56	*	- -	
FLORIDA					
St. Marks NWR (8)					0.4
DDE	7	0.40	0.13-0.72	ND-1.3	
PCB's	5	0.15	0.04-0.26	ND-0.25	
J.N. "Ding" Darling NWR (1)					0.0
DDE	1	0.28	- -	- -	

Appendix III-B (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
FLORIDA (cont.)					
Lake Okeechobee (3)					0.0
DDE	3	0.56	0-1.6	0.34-0.99	
Oxychlordane	1	0.057	0-0.34	ND-0.18	
Cis-chlordane	1	0.038	0-0.22	ND-0.12	
Merritt Island NWR (10)					0.9
DDE	9	0.49	0.20-0.86	ND-1.5	
PCB's	5	0.44	0.01-1.1	ND-3.7	
GEORGIA					
Okefenokee NWR (10)					0.0
DDE	10	0.50	0.32-0.71	0.15-1.1	
Blackbeard Island NWR (1)					0.0
DDE	1	0.62	- -	- -	
SOUTH CAROLINA					
Savannah NWR (7)					0.0
DDE	7	1.4	0.18-3.9	0.23-12	
DDT	1	0.021	0-0.08	ND-0.16	
Dieldrin	4	0.10	0-0.23	ND-0.31	
Mirex	7	0.74	0.25-1.4	0.19-2.5	
NORTH CAROLINA					
Mattamuskeet NWR (3)					0.0
DDE	3	0.47	0.06-1.0	0.33-0.70	
Dieldrin	2	0.28	0-1.2	ND-0.53	

Appendix III-B (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
MARYLAND-VIRGINIA					
Chincoteague Bay (5)					0.2
DDE	5	1.1	0.26-2.5	0.42-2.4	
PCB's	4	0.23	0.04-0.45	ND-0.45	
MARYLAND					
Potomac River (2)					3.1
DDE	2	0.51	*	0.15-0.99	
PCB's	2	1.6	*	0.47-3.7	
NEW JERSEY (1)					0.3
DDE	1	0.77	- -	- -	
PCB's	1	0.25	- -	- -	

Appendix III-C. Little blue heron (N=138). Lipid content = 5.88 ± 0.09%.

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
LOUISIANA					
Sabine NWR (3)					5.0
DDE	3	0.32	0-1.4	0.058-0.68	
Dieldrin	1	0.069	0-0.42	ND-0.22	
Oxychlordane	1	0.050	0-0.30	ND-0.16	
Cis-chlordane	1	0.033	0-0.18	ND-0.10	
PCB's	2	1.6	0-58	ND-9.8	
Lacassine NWR (8)					0.0
DDE	6	0.11	0.04-0.18	ND-0.25	
Dieldrin	3	0.040	0-0.09	ND-0.16	
Atchafalaya Basin (7)					0.0
DDE	7	0.82	0-2.8	0.15-9.4	
DDD	1	0.021	0-0.07	ND-0.15	
DDT	2	0.035	0-0.10	ND-0.17	
Dieldrin	5	0.15	0-0.37	ND-0.73	
PCB's	1	0.012	0-0.04	ND-0.087	
Lake Boeuf (10)					0.7
DDE	9	0.68	0.06-1.6	ND-5.5	
DDD	2	0.040	0-0.11	ND-0.34	
DDT	2	0.033	0-0.08	ND-0.21	
Dieldrin	3	0.069	0-0.17	ND-0.45	
Heptachlor epoxide	2	0.026	0-0.07	ND-0.17	
Oxychlordane	1	0.014	0-0.04	ND-0.14	
Cis-nonachlor	1	0.0092	0-0.03	ND-0.10	
HCB	2	0.018	0-0.05	ND-0.15	
Toxaphene	1	0.0092	0-0.03	ND-0.098	
PCB's	3	0.50	0-1.7	ND-9.6	
Salvador (7)					0.0
DDE	6	0.32	0.04-0.69	ND-1.2	
Dieldrin	1	0.033	0-0.12	ND-0.26	

Appendix III-C (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
ALABAMA					
Stapleton (10)					0.8
DDE	9	0.50	0.22-0.85	ND-1.7	
DDD	1	0.012	0-0.04	ND-0.12	
DDT	1	0.018	0-0.06	ND-0.21	
Dieldrin	2	0.094	0-0.31	ND-1.2	
Oxychlordane	1	0.026	0-0.09	ND-0.29	
Cis-chlordane	1	0.040	0-0.14	ND-0.48	
Cis-nonachlor	1	0.0092	0-0.03	ND-0.091	
PCB's	4	0.42	0-1.1	ND-2.8	
FLORIDA					
St. Marks NWR (10)					0.0
DDE	10	0.87	0.26-1.8	0.046-3.3	
Dieldrin	2	0.021	0-0.05	ND-0.11	
Tampa Bay (1)					15.2
DDE	1	0.21	- -	- -	
Mirex	1	0.91	- -	- -	
PCB's	1	3.2	- -	- -	
J.N. "Ding" Darling NWR (10)					0.0
DDE	8	0.14	0.08-0.21	ND-0.26	
Oxychlordane	6	0.064	0.02-0.11	ND-0.14	
Lake Istokpoga (2)					5.6
DDE	2	1.5	*	0.13-4.6	
Dieldrin	1	1.0	*	ND-3.1	
Oxychlordane	1	0.042	*	ND-0.084	
Cis-chlordane	1	0.045	*	ND-0.090	
Toxaphene	1	0.042	*	ND-0.088	
PCB's	1	8.4	*	ND-88	

Appendix III-C (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
FLORIDA (cont.)					
Merritt Island NWR (10)					1.3
DDE	10	0.41	0.14-0.73	0.090-1.5	
Dieldrin	2	0.028	0-0.07	ND-0.20	
Mirex	1	0.016	0-0.05	ND-0.18	
Oxychlordane	1	0.0092	0-0.03	ND-0.097	
Cis-chlordane	1	0.014	0-0.05	ND-0.16	
PCB's	5	0.54	0-1.4	ND-4.3	
GEORGIA					
Okefenokee NWR (10)					0.1
DDE	6	0.46	0-1.2	ND-6.1	
DDT	1	0.064	0-0.22	ND-0.85	
PCB's	1	0.040	0-0.14	ND-0.48	
SOUTH CAROLINA					
Savannah NWR (2)					3.1
DDE	2	0.45	*	0.33-0.57	
Dieldrin	2	0.49	*	0.35-0.65	
Mirex	2	0.56	*	0.44-0.70	
PCB's	2	1.4	*	0.65-2.5	
Santee NWR (10)					0.3
DDE	10	1.6	1.0-2.4	0.42-3.3	
DDD	1	0.021	0-0.07	ND-0.23	
DDT	6	0.20	0.04-0.37	ND-0.72	
Dieldrin	4	0.13	0-0.32	ND-0.98	
Mirex	5	0.15	0.02-0.30	ND-0.52	
Oxychlordane	1	0.016	0-0.05	ND-0.17	
Cis-chlordane	1	0.0092	0-0.03	ND-0.10	
Toxaphene	1	0.018	0-0.06	ND-0.20	
PCB's	6	0.47	0.14-0.91	ND-1.4	

Appendix III-C (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
NORTH CAROLINA					
Pea Island NWR (6)					0.4
DDE	6	0.81	0.27-1.6	0.28-1.7	
DDT	1	0.023	0-0.09	ND-0.15	
Dieldrin	1	0.072	0-0.28	ND-0.51	
PCB's	5	0.35	0.11-0.65	ND-0.68	
MARYLAND-VIRGINIA					
Chincoteague Bay (5)					0.4
DDE	5	1.9	0.51-4.6	0.57-5.5	
DDT	3	0.089	0-0.36	ND-0.23	
Dieldrin	2	0.64	*	ND-0.48	
PCB's	5	0.83	0.04-2.2	0.25-3.0	
NEW JERSEY (16)					2.6
DDE	16	1.2	0.82-1.6	0.45-3.1	
DDD	3	0.016	0-0.04	ND-0.10	
DDT	1	0.0069	0-0.08	ND-0.099	
Dieldrin	5	0.042	0-0.03	ND-0.39	
Heptachlor epoxide	1	0.012	0-0.04	ND-0.20	
Cis-chlordane	1	0.0092	0-0.03	ND-0.16	
PCB's	16	3.1	1.9-5.0	0.25-8.6	
RHODE ISLAND					
Gould Island (1)					2.2
DDE	1	1.3	--	--	
DDT	1	0.083	--	--	
PCB's	1	2.8	--	--	

Appendix III-C (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
MISSOURI (10)					0.0
DDE	10	1.4	0.7-2.5	0.099-6.4	
DDT	5	0.16	0-0.34	ND-0.87	
Dieldrin	7	0.17	0-0.33	ND-0.71	

Appendix III-D. Cattle egret (N=95). Lipid content = 5.60 ± 0.11%.

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
LOUISIANA					
Sabine NWR (2)					0.0
DDE	1	0.10	*	ND-0.21	
Dieldrin	2	0.36	*	0.26-0.46	
Salvador (10)					0.0
DDE	7	0.27	0.02-0.58	ND-1.8	
DDT	1	0.0092	0-0.03	ND-0.094	
Dieldrin	1	0.030	0-0.11	ND-0.36	
Mirex	5	0.17	0.02-0.34	ND-0.64	
HCB	1	0.0069	0-0.02	ND-0.062	
MISSISSIPPI					
Yazoo NWR (6)					0.2
DDE	6	4.3	0.44-18	0.36-30	
DDD	3	0.12	0-0.01	ND-0.35	
DDT	2	0.33	0-1.4	ND-2.9	
Dieldrin	3	0.57	0-2.3	ND-4.5	
Heptachlor epoxide	1	0.030	0-0.11	ND-0.20	
Mirex	3	0.19	0-0.48	ND-0.64	
Oxychlordane	3	0.11	0-0.30	ND-0.44	
Cis-chlordane	1	0.14	0-0.60	ND-1.2	
Cis-nonachlor	1	0.026	0-0.09	ND-0.16	
Toxaphene	2	0.19	0-0.58	ND-0.78	
PCB's	3	0.88	0-3.5	ND-7.4	

Appendix III-D (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
ALABAMA					
Stapleton (4)					0.0
DDE	3	0.60	0-3.5	ND-3.2	
DDT	1	0.028	0-0.12	ND-0.12	
Dieldrin	2	0.062	0-0.18	ND-0.14	
Heptachlor epoxide	1	0.064	0-0.29	ND-0.28	
Mirex	1	0.035	0-0.16	ND-0.15	
Oxychlordane	2	0.054	0-0.16	ND-0.12	
Cis-chlordane	1	0.16	0-0.87	ND-0.82	
Cis-nonachlor	1	0.023	0-0.10	ND-0.098	
Toxaphene	1	0.074	0-0.34	ND-0.33	
FLORIDA					
St. Marks NWR (1)					0.0
DDE	1	0.24	- -	- -	
Tampa Bay (3)					0.0
DDE	3	0.53	0-2.2	0.15-1.1	
Mirex	2	0.24	0-1.7	ND-0.77	
Oxychlordane	1	0.079	0-0.50	ND-0.26	
Cis-chlordane	1	0.11	0-0.78	ND-0.38	
Sarasota Bay (4)					0.0
DDE	4	0.38	0-1.3	0.092-1.2	
DDT	1	0.052	0-0.24	ND-0.23	
Dieldrin	1	0.20	0-1.2	ND-1.1	
Heptachlor epoxide	1	0.052	0-0.23	ND-0.22	
Mirex	4	0.37	0-1.4	0.11-1.3	
Oxychlordane	1	0.10	0-0.52	ND-0.49	
Cis-chlordane	1	0.16	0-0.89	ND-0.84	
Cis-nonachlor	1	0.023	0-0.10	ND-0.098	

Appendix III-D (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
FLORIDA (cont.)					
Lake Istokpoga (10)					0.0
DDE	8	0.58	0-1.5	ND-5.4	
DDT	2	0.20	0-0.62	ND-2.5	
Dieldrin	2	0.20	0-0.66	ND-3.1	
Mirex	1	0.012	0-0.04	ND-0.11	
Merritt Island NWR (10)					0.6
DDE	8	0.93	0.09-2.4	ND-8.3	
DDT	2	0.04	0-0.19	ND-0.37	
Dieldrin	4	0.23	0-0.65	ND-3.3	
Mirex	2	0.021	0-0.06	ND-0.13	
Oxychlordane	1	0.012	0-0.04	ND-0.12	
Cis-chlordane	1	0.012	0-0.04	ND-0.11	
PCB's	8	0.53	0.09-1.1	ND-3.5	
Orange Lake (10)					0.2
DDE	10	0.66	0-2.0	0.12-17	
Dieldrin	2	0.030	0-0.08	ND-0.22	
Mirex	2	0.028	0-0.07	ND-0.18	
PCB's	5	0.12	0.03-0.22	ND-0.25	
GEORGIA					
Okefenokee NWR (10)					0.4
DDE	7	0.38	0.01-0.88	ND-3.1	
DDT	2	0.072	0-0.23	ND-0.84	
Dieldrin	4	0.27	0-0.93	ND-5.7	
Heptachlor epoxide	1	0.014	0-0.05	ND-0.15	
Mirex	3	0.040	0-0.09	ND-0.15	
PCB's	3	0.14	0-0.37	ND-1.2	
Blackbeard Island NWR (4)					0.6
DDE	4	0.38	0.01-0.89	0.18-0.82	
Mirex	2	0.076	0-0.26	ND-0.23	
PCB's	4	0.25	0.25-0.25	0.25-0.25	

Appendix III-D (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
SOUTH CAROLINA					
Savannah NWR (1)					0.1
DDE	1	7.0	- -	- -	
DDT	1	0.36	- -	- -	
Mirex	1	2.9	- -	- -	
PCB's	1	0.70	- -	- -	
Santee NWR (10)					0.1
DDE	10	1.9	1.1-3.1	0.27-4.6	
DDD	1	0.012	0-0.04	ND-0.11	
DDT	6	0.16	0-0.33	ND-0.92	
Dieldrin	5	0.27	0.02-0.57	ND-1.2	
Mirex	5	0.15	0.02-0.30	ND-0.57	
PCB's	5	0.19	0.03-0.37	ND-0.57	
MARYLAND					
Potomac River (10)					0.2
DDE	10	1.2	0.3-2.7	0.14-10.0	
DDT	5	0.069	0.01-0.13	ND-0.22	
Dieldrin	6	0.27	0-0.82	ND-4.3	
Heptachlor epoxide	1	0.0092	0-0.02	ND-0.084	
Oxychlordane	1	0.030	0-0.11	ND-0.36	
Cis-chlordane	1	0.023	0-0.08	ND-0.26	
PCB's	6	0.24	0-0.56	ND-1.9	

Appendix III-E. Great egret (N=111). Lipid content = 5.51 ± 0.09%.

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
LOUISIANA					
Sabine NWR (19)					0.4
DDE	19	0.78	0.56-1.0	0.29-2.8	
DDD	2	0.035	0-0.10	ND-0.63	
DDT	6	0.050	0.01-0.09	ND-0.32	
Dieldrin	6	0.11	0-0.25	ND-2.0	
Heptachlor epoxide	1	0.0046	0-0.01	ND-0.080	
Oxychlordane	1	0.0069	0-0.01	ND-0.12	
Cis-chlordane	2	0.016	0-0.04	ND-0.24	
Cis-nonachlor	1	0.0046	0-0.02	ND-0.098	
PCB's	8	0.30	0.09-0.54	ND-1.9	
Atchafalaya Basin (11)					0.5
DDE	11	2.1	1.2-3.2	0.40-5.9	
DDD	6	0.19	0.04-0.37	ND-0.68	
DDT	11	0.36	0.18-0.56	0.089-1.0	
Dieldrin	10	1.1	0.4-2.0	ND-3.3	
Heptachlor epoxide	1	0.0092	0-0.03	ND-0.11	
Mirex	1	0.012	0-0.04	ND-0.14	
Cis-chlordane	2	0.026	0-0.06	ND-0.17	
Cis-nonachlor	1	0.014	0-0.04	ND-0.15	
HCB	1	0.0069	0-0.26	ND-0.090	
Toxaphene	1	0.0092	0-0.03	ND-0.11	
Endrin	2	0.016	0-0.04	ND-0.097	
PCB's	11	0.97	0.38-1.8	0.28-5.9	
Barataria Bay (1)					0.9
DDE	1	0.49	- -	- -	
DDD	1	0.080	- -	- -	
Dieldrin	1	0.080	- -	- -	
PCB's	1	0.43	- -	- -	
FLORIDA					
Cedar Keys NWR (1)					0.0
DDE	1	1.0	- -	- -	
Heptachlor epoxide	1	0.091	- -	- -	

Appendix III-E (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
FLORIDA (cont.)					
Chassahowitzka NWR (7)					0.3
DDE	7	0.42	0.20-0.69	0.15-1.0	
Dieldrin	1	0.014	0-0.05	ND-0.10	
Mirex	1	0.091	0-0.36	ND-0.85	
Oxychlordane	1	0.014	0-0.05	ND-0.10	
Cis-chlordane	1	0.038	0-0.14	ND-0.30	
PCB's	2	0.13	0-0.39	ND-0.62	
Sarasota Bay (1)					1.9
DDE	1	0.28	- -	- -	
Dieldrin	1	0.14	- -	- -	
Mirex	1	0.23	- -	- -	
PCB's	1	0.54	- -	- -	
J.N. "Ding" Darling NWR (10)					0.7
DDE	10	0.98	0.29-2.0	0.38-9.0	
DDD	1	0.028	0-0.09	ND-0.31	
Dieldrin	1	0.091	0-0.33	ND-1.4	
Oxychlordane	1	0.014	0-0.04	ND-0.14	
Cis-chlordane	2	0.023	0-0.06	ND-0.14	
PCB's	9	0.65	0.34-1.0	ND-1.7	
Merritt Island NWR (13)					2.3
DDE	13	0.66	0.40-0.96	0.23-1.8	
Dieldrin	5	0.10	0-0.21	ND-0.64	
Oxychlordane	1	0.018	0-0.06	ND-0.26	
Cis-chlordane	3	0.042	0-0.09	ND-0.26	
PCB's	12	1.5	0.76-2.5	ND-12	
GEORGIA					
Okefenokee NWR (2)					0.0
DDE	2	2.3	*	0.57-6.1	
Mirex	1	0.20	*	ND-0.45	

Appendix III-E (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
GEORGIA (cont.)					
Blackbeard Island NWR (3)					0.1
DDE	3	2.1	0-14	0.54-4.6	
DDD	1	0.045	0-0.26	ND-0.14	
DDT	1	0.32	0-3.4	ND-1.3	
Mirex	1	0.057	0-0.34	ND-0.18	
PCB's	2	0.16	0-0.60	ND-0.25	
Wassaw NWR (1)					0.2
DDE	1	1.4	- -	- -	
Mirex	1	2.0	- -	- -	
PCB's	1	0.25	- -	- -	
SOUTH CAROLINA					
Drum Island (1)					2.0
DDE	1	0.38	- -	- -	
Mirex	1	0.10	- -	- -	
PCB's	1	0.77	- -	- -	
Cape Romain NWR (11)					0.4
DDE	11	2.2	1.1-3.9	0.43-9.0	
DDD	2	0.021	0-0.05	ND-0.16	
DDT	6	0.13	0.02-0.24	ND-0.46	
Dieldrin	7	0.084	0.03-0.14	ND-0.27	
Mirex	7	0.12	0.04-0.22	ND-0.36	
Cis-chlordane	2	0.023	0-0.06	ND-0.15	
PCB's	10	0.83	0.32-1.5	ND-3.4	

Appendix III-E (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
NORTH CAROLINA					
Pea Island NWR (2)					0.4
DDE	2	3.8	*	1.7-7.6	
DDT	2	0.16	*	0.12-0.21	
Dieldrin	1	0.059	*	ND-0.12	
Cis-chlordane	1	0.054	*	ND-0.11	
PCB's	2	1.6	*	1.4-1.8	
MARYLAND-VIRGINIA					
Chincoteague Bay (7)					0.5
DDE	7	2.4	1.9-3.1	1.6-3.4	
DDD	1	0.023	0-0.08	ND-0.18	
DDT	2	0.047	0-0.13	ND-0.21	
Dieldrin	2	0.057	0-0.14	ND-0.22	
Cis-chlordane	1	0.012	0-0.04	ND-0.083	
PCB's	7	1.3	0.8-2.0	0.57-2.3	
NEW JERSEY (6)					1.0
DDE	6	4.2	2.6-6.6	2.5-7.4	
DDD	3	0.054	0-0.12	ND-0.13	
DDT	4	0.18	0-0.50	ND-0.83	
Dieldrin	2	0.064	0-0.19	ND-0.29	
Oxychlordane	1	0.018	0-0.06	ND-0.11	
Cis-chlordane	1	0.018	0-0.06	ND-0.11	
PCB's	6	4.0	2.7-5.7	2.1-5.8	

Appendix III-E (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
NEW YORK					
Long Island (4)					3.1
DDE	4	2.8	1.2-5.4	1.4-4.1	
DDD	4	0.14	0.07-0.20	0.092-0.18	
DDT	2	0.069	0-0.22	ND-0.17	
Dieldrin	4	0.13	0.06-0.20	0.092-0.18	
Oxychlordane	3	0.091	0-0.20	ND-0.15	
Cis-chlordane	4	0.39	0.19-0.64	0.26-0.58	
Cis-nonachlor	1	0.023	0-0.10	ND-0.097	
PCB's	4	8.6	3.4-20	4.1-16.0	
MICHIGAN					
Detroit River (2)					3.4
DDE	2	1.9	*	1.9-2.0	
DDD	2	0.16	*	0.11-0.22	
DDT	1	0.045	*	ND-0.089	
Dieldrin	2	0.46	*	0.14-0.88	
Mirex	1	0.072	*	ND-0.15	
Cis-chlordane	2	0.11	*	0.10-0.13	
Toxaphene	1	0.066	*	ND-0.14	
PCB's	2	6.4	*	5.8-7.0	

Appendix III-E (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
MINNESOTA					
Pelican Lake & Lake Johanna (9)					1.4
DDE	9	2.0	1.2-3.1	0.39-4.4	
DDD	5	0.076	0.01-0.14	ND-0.20	
DDT	5	0.17	0.01-0.39	ND-0.79	
Dieldrin	6	0.18	0.02-0.33	ND-0.60	
Heptachlor epoxide	3	0.040	0-0.09	ND-0.16	
Mirex	1	0.018	0-0.06	ND-0.17	
Oxychlordane	1	0.021	0-0.07	ND-0.21	
Cis-chlordane	4	0.15	0-0.37	ND-0.99	
Toxaphene	4	0.057	0-0.11	ND-0.20	
PCB's	8	2.9	0.8-7.3	ND-12	

Appendix III-F. Snowy egret (N=170). Lipid content = 6.38 ± 0.13%.

Site (N) / Chemical	Number with residues	Residues in ppm (wet weight) Geometric	95%	Range	PCB/DDE ratio
LOUISIANA					
Sabine NWR (10)					0.9
DDE	10	0.57	0.20-1.0	0.22-3.3	
DDD	1	0.0092	0-0.03	ND-0.094	
DDT	1	0.0092	0-0.03	ND-0.10	
Dieldrin	4	0.16	0.01-0.33	ND-0.51	
Heptachlor epoxide	1	0.012	0-0.04	ND-0.11	
Cis-chlordane	1	0.0092	0-0.02	ND-0.084	
PCB's	7	0.51	0.12-1.0	ND-3.1	
Atchafalaya Basin (2)					0.6
DDE	2	1.9	*	1.2-2.8	
DDT	2	0.40	*	0.32-0.49	
Dieldrin	2	0.27	*	0.12-0.45	
Heptachlor epoxide	1	0.042	*	ND-0.084	
PCB's	2	1.2	*	1.2-1.3	
Lake Boeuf (10)					0.7
DDE	10	1.0	0.3-2.1	0.17-6.3	
DDD	1	0.040	0-0.14	ND-0.48	
Dieldrin	1	0.014	0-0.04	ND-0.14	
PCB's	9	0.67	0.34-1.1	ND-2.1	
Salvador (7)					1.6
DDE	7	0.26	0.10-0.45	0.098-0.57	
PCB's	4	0.43	0.04-0.97	ND-1.3	
Barataria Bay (2)					1.8
DDE	2	0.25	*	0.21-0.29	
PCB's	2	0.46	*	0.46-0.46	

Appendix III-F (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
ALABAMA					
Cat Island (10)					1.2
DDE	10	1.2	0.6-2.1	0.38-5.0	
DDD	1	0.014	0-0.05	ND-0.15	
DDT	2	0.054	0-0.16	ND-0.52	
Dieldrin	3	0.040	0-0.09	ND-0.21	
PCB's	10	1.5	0.82-2.6	0.53-5.0	
FLORIDA					
St. Marks NWR (10)					1.0
DDE	10	1.9	1.0-3.1	0.33-5.2	
Dieldrin	2	0.050	0-0.13	ND-0.36	
Heptachlor epoxide	1	0.021	0-0.07	ND-0.23	
Mirex	1	0.030	0-0.11	ND-0.36	
Oxychlordane	2	0.030	0-0.08	ND-0.23	
Cis-chlordane	4	0.050	0-0.10	ND-0.16	
PCB's	10	1.9	0.6-4.2	0.25-11	
Cedar Keys NWR (10)					0.6
DDE	10	0.37	0.19-0.58	0.098-0.93	
DDT	2	0.018	0-0.02	ND-0.096	
Dieldrin	1	0.012	0-0.05	ND-0.12	
PCB's	6	0.24	0.08-0.43	ND-0.59	
Sarasota Bay (2)					2.3
DDE	2	0.64	*	0.48-0.81	
DDD	1	0.042	*	ND-0.085	
Dieldrin	1	0.11	*	ND-0.23	
Mirex	1	0.18	*	ND-0.40	
Oxychlordane	2	0.21	*	0.16-0.26	
Cis-chlordane	2	0.30	*	0.21-0.40	
PCB's	2	1.5	*	1.2-1.8	

Appendix III-F (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
FLORIDA (cont.)					
J.N. "Ding" Darling NWR (7)					0.5
DDE	7	0.59	0.32-0.91	0.23-1.2	
DDD	1	0.026	0-0.09	ND-0.20	
Oxychlordane	1	0.062	0-0.23	ND-0.53	
Cis-chlordane	1	0.062	- -	ND-0.51	
PCB's	4	0.29	0.02-0.61	ND-0.76	
Everglades NP (2)					0.0
DDE	2	0.19	*	0.096-0.29	
Lake Istokpoga (5)					0.5
DDE	5	0.96	0.4-1.8	0.37-1.7	
DDD	1	0.066	0-0.28	ND-0.38	
Oxychlordane	1	0.054	0-0.23	ND-0.31	
Cis-chlordane	1	0.091	0-0.39	ND-0.55	
PCB's	4	0.46	0-1.1	ND-1.3	
Merritt Island NWR (10)					1.0
DDE	10	0.54	0.12-1.1	0.090-4.2	
DDT	1	0.014	0-0.05	ND-0.16	
Dieldrin	2	0.042	0-0.12	ND-0.35	
PCB's	4	0.53	0.02-1.3	ND-2.8	
GEORGIA					
Okefenokee NWR (1)					1.1
DDE	1	0.74	- -	- -	
PCB's	1	0.81	- -	- -	
Blackbeard Is. NWR (6)					0.3
DDE	6	0.80	0.26-1.6	0.25-1.8	
Dieldrin	4	0.26	0-0.58	ND-0.71	
Mirex	2	0.047	0-0.13	ND-0.18	
PCB's	2	0.21	0-0.78	ND-1.5	

Appendix III-F (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
GEORGIA (cont.)					
Wassaw NWR (1)					0.0
DDE	1	0.25	- -	- -	
SOUTH CAROLINA					
Cape Romain NWR (10)					0.7
DDE	10	0.79	0.49-1.2	0.36-2.2	
DDD	1	0.0092	0-0.03	ND-0.098	
DDT	1	0.0092	0-0.03	ND-0.10	
Dieldrin	3	0.21	0-0.78	ND-4.7	
Oxychlordane	1	0.064	0-0.23	ND-0.88	
Cis-chlordane	2	0.066	0-0.19	ND-0.64	
Cis-nonachlor	1	0.018	0-0.06	ND-0.21	
PCB's	6	0.57	0-1.5	ND-7.7	
NORTH CAROLINA					
Pea Island NWR (5)					0.3
DDE	5	1.0	0.6-1.5	0.61-1.6	
DDT	2	0.052	0-0.15	ND-0.15	
Dieldrin	3	0.19	0-0.69	ND-0.96	
PCB's	3	0.29	0-0.74	ND-0.65	
MARYLAND-VIRGINIA					
Chincoteague Bay (10)					0.8
DDE	10	2.0	1.1-3.3	0.58-9.2	
DDT	3	0.11	0-0.33	ND-1.2	
Dieldrin	3	0.086	0-0.20	ND-0.42	
PCB's	10	1.7	0.5-3.9	0.55-27	

Appendix III-F (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
NEW JERSEY (11)					1.3
DDE	11	1.8	1.0-3.1	0.50-12	
DDD	4	0.10	0-0.26	ND-0.94	
DDT	1	0.15	0-0.56	ND-3.6	
Dieldrin	3	0.038	0-0.08	ND-0.18	
PCB's	11	2.3	1.6-3.2	0.72-4.0	
NEW YORK					
Long Island (12)					
DDE	12	2.0	1.2-3.0	0.41-4.4	
DDD	8	0.16	0.05-0.28	ND-0.62	
DDT	5	0.11	0.01-0.21	ND-0.43	
Dieldrin	9	0.183	0.08-0.29	ND-0.54	
Oxychlordane	4	0.042	0-0.08	ND-0.16	
Cis-chlordane	8	0.14	0.06-0.21	ND-0.36	
PCB's	12	7.9	4.6-13	2.3-29	
Gardiner's Island (2)					0.4
DDE	2	11.0	*	5.8-19	
DDD	2	2.0	*	0.73-4.1	
DDT	1	0.12	*	ND-0.26	
Dieldrin	1	0.091	*	ND-0.19	
PCB's	2	4.2	*	3.4-5.2	
RHODE ISLAND					
Gould Island (12)					1.1
DDE	12	2.8	1.3-5.3	0.30-20	
DDD	2	0.023	0-0.06	ND-0.17	
DDT	7	0.21	0-0.46	ND-1.6	
Dieldrin	10	0.41	0.16-0.71	ND-1.8	
Oxychlordane	2	0.059	0-0.16	ND-0.62	
Cis-chlordane	1	0.0069	0-0.02	ND-0.095	
PCB's	9	3.0	1.0-7.1	ND-29	

Appendix III-F (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
MASSACHUSETTS					
Martha's Vineyard (2)					3.0
DDE	2	0.53	*	0.37-0.72	
DDD	1	0.091	*	ND-0.19	
DDT	1	0.059	*	ND-0.12	
Dieldrin	2	0.099	*	0.078-0.12	
PCB's	2	1.6	*	1.6-1.6	
House Island (11)					2.0
DDE	11	3.1	1.7-5.3	1.1-20	
DDD	5	0.094	0-0.19	ND-0.52	
DDT	5	0.069	0.01-0.13	ND-0.22	
Dieldrin	7	0.26	0.01-0.57	ND-1.9	
Oxychlordane	1	0.030	0-0.10	ND-0.39	
Cis-chlordane	3	0.030	0-0.06	ND-0.13	
PCB's	11	6.1	2.8-12	0.57-54	

Appendix III-G. Louisiana heron (N=153). Lipid content = 6.29 ± 0.11%.

Site (N) / Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
LOUISIANA					
Sabine NWR (8)					0.9
DDE	7	0.55	0.21-0.98	ND-1.4	
DDD	4	0.076	0-0.16	ND-0.26	
DDT	1	0.0092	0-0.03	ND-0.078	
Dieldrin	5	0.10	0.01-0.20	ND-0.35	
PCB's	6	0.49	0.14-0.95	ND-1.8	
Lacassine NWR (8)					0.5
DDE	8	0.60	0-1.7	0.098-4.0	
DDD	1	0.033	0-0.12	ND-0.30	
DDT	2	0.030	0-0.08	ND-0.17	
Dieldrin	7	0.36	0.02-0.80	ND-1.6	
Mirex	1	0.14	0-0.54	ND-1.8	
PCB's	5	0.31	0.06-0.61	ND-1.0	
Atchafalaya Basin (10)					1.0
DDE	10	1.2	0.4-2.3	0.35-8.7	
DDT	8	0.23	0.03-0.47	ND-1.4	
Dieldrin	4	0.052	0-0.10	ND-0.17	
Oxychlordane	1	0.012	0-0.004	ND-0.12	
Toxaphene	2	0.052	0-0.15	ND-0.48	
PCB's	7	1.2	0.4-2.4	ND-4.5	
Lake Boeuf (10)					0.5
DDE	10	0.68	0.17-1.4	0.15-5.4	
DDD	2	0.057	0-0.17	ND-0.59	
DDT	2	0.040	0-0.12	ND-0.36	
Dieldrin	2	0.016	0-0.04	ND-0.094	
Heptachlor epoxide	1	0.018	0-0.06	ND-0.20	
Oxychlordane	1	0.012	0-0.04	ND-0.11	
PCB's	7	0.32	0.13-0.55	ND-0.96	

Appendix III-G (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
LOUISIANA (cont.)					
Salvador (8)					2.2
DDE	8	0.50	0.26-0.80	0.11-1.2	
Dieldrin	4	0.059	0-0.12	ND-0.14	
Oxychlordane	1	0.012	0-0.04	ND-0.096	
PCB's	5	1.1	0.2-2.6	ND-4.0	
Barataria Bay (10)					3.3
DDE	10	0.42	0.31-0.54	0.18-0.73	
Dieldrin	1	0.0092	0-0.03	ND-0.097	
PCB's	10	1.4	0.9-2.0	0.47-3.5	
ALABAMA					
Cat Island (10)					1.3
DDE	10	0.98	0.49-1.6	0.32-4.4	
DDD	1	0.014	0-0.05	ND-0.16	
DDT	1	0.12	0-0.43	ND-2.0	
Dieldrin	1	0.016	0-0.05	ND-0.18	
PCB's	10	1.3	0.9-1.7	0.68-2.8	
FLORIDA					
St. Marks NWR (11)					1.1
DDE	11	1.3	0.5-2.6	0.15-5.9	
DDD	2	0.072	0-0.22	ND-0.86	
DDT	2	0.081	0-0.26	ND-1.1	
Dieldrin	1	0.084	0-0.29	ND-1.4	
Heptachlor epoxide	1	0.0069	0-0.02	ND-0.086	
Oxychlordane	1	0.012	0-0.04	ND-0.14	
Cis-chlordane	1	0.042	0-0.14	ND-0.56	
Cis-nonachlor	1	0.012	0-0.04	ND-0.14	
PCB's	9	1.4	0.3-3.3	ND-12	

Appendix III-G (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
FLORIDA (cont.)					
Cedar Keys NWR (2)					0.6
DDE	2	0.21	*	0.20-0.23	
PCB's	1	0.12	*	ND-0.25	
Chassahowitzka NWR (5)					1.3
DDE	4	0.15	0-0.32	ND-0.35	
PCB's	1	0.20	0-1.0	ND-1.5	
Tampa Bay (1)					2.6
DDE	1	0.38	- -	- -	
PCB's	1	1.0	- -	- -	
Sarasota Bay (1)					1.8
DDE	1	1.1	- -	- -	
Dieldrin	1	0.086	- -	- -	
Mirex	1	0.27	- -	- -	
Oxychlordane	1	0.13	- -	- -	
Cis-chlordane	1	0.13	- -	- -	
PCB's	1	2.0	- -	- -	
J.N. "Ding" Darling NWR (10)					0.3
DDE	9	0.41	0.20-0.65	ND-1.2	
Dieldrin	1	0.014	0-0.04	ND-0.14	
Cis-chlordane	2	0.028	0-0.08	ND-0.18	
Cis-nonachlor	1	0.0092	0-0.03	ND-0.086	
PCB's	5	0.13	0.02-0.26	ND-0.53	
Everglades NP (10)					0.0
DDE	10	0.16	0.10-0.23	0.097-0.38	
Lake Istokpoga (5)					0.4
DDE	5	0.50	0-1.4	0.16-1.8	
Toxaphene	1	0.016	0-0.07	ND-0.089	
PCB's	1	0.19	0-0.94	ND-1.4	

Appendix III-G (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
FLORIDA (cont.)					
Merritt Island NWR (9)					1.6
DDE	9	0.49	0.26-0.75	0.18-1.0	
DDT	3	0.15	0-0.35	ND-0.65	
Dieldrin	6	0.17	0.04-0.32	ND-0.49	
Mirex	1	0.026	0-0.09	ND-0.26	
PCB's	8	0.81	0.43-1.3	ND-1.6	
GEORGIA					
Blackbeard Island NWR (8)					0.4
DDE	8	0.68	0.33-1.1	0.17-1.7	
DDT	2	0.040	0-0.11	ND-0.26	
Dieldrin	1	0.012	0-0.04	ND-0.10	
PCB's	8	0.28	0.22-0.35	0.21-0.44	
Wassaw NWR (1)					1.5
DDE	1	0.33	- -	- -	
Mirex	1	0.65	- -	- -	
PCB's	1	0.51	- -	- -	
SOUTH CAROLINA					
Savannah NWR (1)					0.9
DDE	1	0.54	- -	- -	
Mirex	1	0.13	- -	- -	
PCB's	1	0.50	- -	- -	
Cape Romain NWR (10)					0.5
DDE	10	0.36	0.25-0.49	0.11-0.73	
Dieldrin	2	0.042	0-0.12	ND-0.36	
Mirex	1	0.014	0-0.04	ND-0.14	
PCB's	7	0.17	0.08-0.26	ND-0.26	

Appendix III-G (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
NORTH CAROLINA					
Pea Island NWR (6)					0.4
DDE	6	0.60	0.09-1.3	0.11-2.0	
DDT	1	0.042	0-0.16	ND-0.29	
PCB's	5	0.21	0.10-0.33	ND-0.28	
MARYLAND-VIRGINIA					
Chincoteague Bay (6)					1.1
DDE	6	0.88	0.04-2.4	0.23-4.5	
DDD	1	0.021	0-0.08	ND-0.14	
Dieldrin	1	0.023	0-0.09	ND-0.15	
Mirex	1	0.064	0-0.25	ND-0.45	
Oxychlordane	1	0.014	0-0.05	ND-0.092	
Cis-chlordane	1	0.038	0-0.14	ND-0.25	
PCB's	6	0.97	0-3.0	0.25-6.0	
NEW JERSEY (3)					1.2
DDE	3	1.1	0.2-2.7	0.63-1.6	
DDD	1	0.030	0-0.17	ND-0.091	
DDT	1	0.057	0-0.34	ND-0.18	
Dieldrin	1	0.030	0-0.17	ND-0.096	
PCB's	3	1.3	0-4.9	0.53-2.1	

Appendix III-H. Yellow-crowned night heron (N=34). Lipid content = 6.38 ± 0.24%.

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
LOUISIANA					
Lacassine NWR (11)					0.0
DDE	9	0.18	0.04-0.34	ND-1.0	
Dieldrin	3	0.050	0-0.12	ND-0.39	
Atchafalaya Basin (10)					0.0
DDE	9	0.88	0.02-2.4	ND-12	
DDT	1	0.012	0-0.04	ND-0.11	
Dieldrin	1	0.018	0-0.64	ND-0.21	
FLORIDA					
Blountstown (10)					0.0
DDE	10	0.35	0.21-0.50	0.20-0.89	
DDT	1	0.0092	0-0.03	ND-0.096	
Mirex	1	0.040	0-0.14	ND-0.49	
St. Marks NWR (1)		ND for all chemicals			0.0
GEORGIA					
Wassaw NWR (1)					0.0
DDE	1	0.31	- -	- -	
Mirex	1	0.52	- -	- -	
SOUTH CAROLINA					
Drum Island (1)					3.5
DDE	1	1.5	- -	- -	
DDD	1	0.11	- -	- -	
Mirex	1	0.21	- -	- -	
Oxychlordane	1	0.18	- -	- -	
PCB's	1	5.3	- -	- -	

Appendix III-J. Least bittern (N=30). Lipid content = 6.42 ± 0.19%.

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
LOUISIANA					
Sabine NWR (9)					0.0
DDE	9	0.35	0.22-0.49	0.16-0.59	
Dieldrin	1	0.030	0-0.11	ND-0.32	
FLORIDA					
St. Marks NWR (2)					0.4
DDE	2	1.1	*	0.67-1.6	
DDD	1	0.059	*	ND-0.12	
DDT	1	0.050	*	ND-0.10	
Dieldrin	1	1.1	*	ND-3.4	
PCB's	1	0.48	*	ND-1.2	
Lake Okeechobee (9)					0.0
DDE	9	1.0	0.8-1.4	0.73-2.1	
Cis-chlordane	1	0.0092	0-0.04	ND-0.096	
Merritt Island NWR (8)					0.6
DDE	8	0.29	0.09-0.53	0.080-1.0	
PCB's	3	0.17	0-0.44	ND-0.88	
Payne's Prairie (2)					0.0
DDE	2	0.67	*	0.21-1.3	

Appendix III-K. American bittern (N=1). Lipid content = 6.70%.

Site (N) Chemical	Number with residues	Residues in ppm (wet weight)			PCB/DDE ratio
		Geometric mean	95% C.I.	Range	
MINNESOTA					
Fergus Falls (1)					0.0
DDE	1	0.20	- -	- -	

Appendix III-L. Glossy ibis (N=70). Lipid content = 5.38 ± 0.15%.

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
LOUISIANA					
Barataria Bay (2)					0.0
DDE	2	0.23	*	0.20-0.26	
FLORIDA					
Merritt Island NWR (5)					0.0
DDE	5	0.34	0.03-0.75	0.13-0.92	
DDT	1	0.045	0-0.18	ND-0.24	
Cis-chlordane	1	0.021	0-0.08	ND-0.11	
SOUTH CAROLINA					
Cape Romaine NWR (5)					0.0
DDE	5	1.5	0.2-4.2	0.46-5.4	
Dieldrin	3	0.20	0-0.67	ND-0.89	
NORTH CAROLINA					
Pea Island NWR (7)					0.0
DDE	7	1.8	0.92-3.2	0.53-3.3	
DDT	5	0.17	0-0.39	ND-0.71	
Dieldrin	4	0.13	0-0.28	ND-0.43	
PCB's	1	0.032	0-0.12	ND-0.25	
MARYLAND-VIRGINIA					
Chincoteague Bay (10)					0.1
DDE	10	2.0	1.0-3.6	0.57-13	
DDD	2	0.026	0-0.07	ND-0.14	
DDT	8	0.45	0.08-0.95	ND-2.3	
Dieldrin	5	0.29	0.01-0.64	ND-1.6	
PCB's	5	0.16	0.02-0.31	ND-0.66	

Appendix III-L (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
NEW JERSEY (15)					0.2
DDE	15	1.5	0.8-2.4	0.21-8.2	
DDD	5	0.062	0-0.13	ND-0.49	
DDT	10	0.14	0.06-0.22	ND-0.46	
Dieldrin	5	0.18	0-0.42	ND-1.8	
Cis-chlordane	3	0.016	0-0.04	ND-0.10	
PCB's	8	0.29	0.04-0.61	ND-3.0	
NEW YORK					
Long Island (22)					0.3
DDE	22	1.8	1.2-2.6	0.61-15	
DDD	13	0.14	0.06-0.21	ND-0.74	
DDT	10	0.12	0.04-0.20	ND-0.81	
Dieldrin	12	0.20	0.08-0.32	ND-1.0	
Cis-chlordane	14	0.086	0.05-0.12	ND-0.27	
PCB's	14	0.59	0.31-0.91	ND-2.5	
Gardiner's Island (4)					0.1
DDE	4	0.96	0-3.6	0.31-3.3	
DDT	1	0.13	0-0.66	ND-0.62	
Dieldrin	2	0.069	0-0.22	ND-0.18	
HCB	1	0.026	0-0.11	ND-0.11	
PCB's	1	0.11	0-0.56	ND-0.53	

Appendix III-M. White-faced ibis (N=14). Lipid content = 4.97 ± 0.22%.

Site (N) / Chemical	Number with residues	Residues in ppm (wet weight)			PCB/DDE ratio
		Geometric mean	95% C.I.	Range	
LOUISIANA					
Sabine NWR (10)					0.0
DDE	10	0.35	0.26-0.43	0.13-0.49	
Dieldrin	7	0.64	0-1.7	ND-5.4	
Barataria Bay (4)					0.0
DDE	4	0.27	0-0.63	0.096-0.58	

Appendix III-N. White ibis ($\underline{N}$=53). Lipid content = 5.96 $\pm$ 0.17%.

Site ($\underline{N}$) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
LOUISIANA					
Barataria Bay (6)					0.4
DDE	6	0.28	0.07-0.52	0.12-0.73	
DDT	1	0.059	0-0.23	ND-0.41	
Dieldrin	1	0.033	0-0.12	ND-0.21	
PCB's	2	0.12	0-0.34	ND-0.43	
FLORIDA					
Cedar Keys NWR (10)					1.0
DDE	9	0.12	0.09-0.16	ND-0.19	
Mirex	1	0.014	0-0.05	ND-0.15	
PCB's	5	0.12	0.03-0.22	ND-0.25	
Tampa Bay (3)					0.4
DDE	3	0.67	0-3.4	0.29-1.6	
DDT	1	0.030	0-0.18	ND-0.097	
Dieldrin	1	0.028	0-0.16	ND-0.087	
Heptachlor epoxide	1	0.14	0-1.0	ND-0.48	
Oxychlordane	1	0.033	0-0.18	ND-0.10	
PCB's	1	0.25	0-2.2	ND-0.93	
Sarasota Bay (2)					0.0
DDE	2	0.29	*	0.19-0.40	
J.N. "Ding" Darling NWR (1)					0.0
DDE	1	0.11	- -	- -	
Everglades NP (10)					0.0
DDE	6	0.080	0.02-0.14	ND-0.25	
Dieldrin	1	0.012	0-0.04	ND-0.13	
Lake Istokpoga (11)					0.0
DDE	7	0.14	0.04-0.24	ND-0.52	
DDT	1	0.014	0-0.04	ND-0.16	
Dieldrin	1	0.033	0-0.11	ND-0.41	

Appendix III-N (cont.).

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
FLORIDA (cont.)					
Merritt Island NWR (10)					0.8
DDE	9	0.27	0.10-0.45	ND-0.84	
DDT	1	0.014	0-0.05	ND-0.15	
Dieldrin	1	0.012	0-0.04	ND-0.13	
Mirex	1	0.014	0-0.05	ND-0.16	
PCB's	5	0.21	0-0.48	ND-1.4	

Appendix III-O. Roseate spoonbill (N=24). Lipid content = 5.73 ± 0.16%.

Site (N) Chemical	Number with residues	Residues in ppm (wet weight) Geometric mean	95% C.I.	Range	PCB/DDE ratio
LOUISIANA					
Sabine NWR (18)					0.2
DDE	18	0.76	0.52-1.0	0.36-3.0	
DDD	13	0.091	0.05-0.14	ND-0.26	
DDT	6	0.081	0.01-0.15	ND-0.56	
Dieldrin	10	0.047	0.02-0.07	ND-0.17	
Cis-chlordane	1	0.0019	0-0.01	ND-0.40	
PCB's	9	0.19	0.06-0.35	ND-1.2	
FLORIDA					
Everglades NP (6)					0.3
DDE	6	0.42	0.23-0.64	0.25-0.76	
Cis-chlordane	1	0.012	0-0.04	ND-0.075	
PCB's	1	0.12	0-0.50	ND-0.98	

Appendix IV

Mean DDE and PCB concentrations (ppm, wet weight) in eggs of anhingas and wading birds for selected sites, 1972-73. Collection sites are coded as in Table 1. Although all species means are listed for visual comparison, statistical comparisons included only those species with at least five samples for that site, and these means are followed by letters A-C in the tables. For each site, species means that do not share the same letters are significantly different ($P < 0.05$) from each other (DDE and PCB's considered separately). Means of 0.0 ppm reflect that DDE or PCB's were not detected in certain species for that site, or that the mean was less than 0.01 ppm.

Appendix IV.

DDE		PCB's	
Species	Geometric mean	Species	Geometric mean
	1. Sabine NWR, La.		
Great blue heron	3.8	Little blue heron	1.6
Bl.-cr. night heron	0.89 A	Great blue heron	1.2
Great egret	0.78 A	Snowy egret	0.51 A
Roseate spoonbill	0.76 A	Louisiana heron	0.49 A
Snowy egret	0.57 A	Bl.-cr. night heron	0.46 A
Louisiana heron	0.55 A	Great egret	0.30 A
Green heron	0.41 A	Roseate spoonbill	0.19 A
Least bittern	0.35 A	Green heron	0.077 A
White-faced ibis	0.35 A	White-faced ibis	0.0 A
Little blue heron	0.32	Least bittern	0.0 A
Cattle egret	0.10	Cattle egret	0.0
	2. Lacassine NWR, La.		
Anhinga	0.79	Louisiana heron	0.31 A
Bl.-cr. night heron	0.69 A	Bl.-cr. night heron	0.25 A
Louisiana heron	0.60 A	Yel.-cr. night heron	0.0 B
Green heron	0.47 A	Little blue heron	0.0 B
Yel.-cr. night heron	0.18 A	Green heron	0.0 B
Little blue heron	0.11 A	Anhinga	0.0
	3. Atchafalaya Basin, La.		
Anhinga	2.1 A	Snowy egret	1.2
Great egret	2.1 A	Louisiana heron	1.2 A
Snowy egret	1.9	Great egret	0.97 AB
Green heron	1.3 A	Green heron	0.60 ABC
Louisiana heron	1.2 A	Anhinga	0.23 ABC
Yel.-cr. night heron	0.88 A	Bl.-cr. night heron	0.20
Little blue heron	0.82 A	Little blue heron	0.012 BC
Bl.-cr. night heron	0.35	Yel.-cr. night heron	0.0 C

Appendix IV (cont.).

DDE		PCB's	
Species	Geometric mean	Species	Geometric mean
	4. Lake Boeuf, La.		
Snowy egret	1.0 A	Snowy egret	0.67 A
Little blue heron	0.68 A	Little blue heron	0.50 A
Louisiana heron	0.68 A	Louisiana heron	0.32 A
Green heron	0.49 A	Green heron	0.0 A
	5. Salvador, La.		
Louisiana heron	0.50 A	Louisiana heron	1.1 A
Little blue heron	0.32 A	Snowy egret	0.43 AB
Cattle egret	0.27 A	Cattle egret	0.0 B
Snowy egret	0.26 A	Little blue heron	0.0 B
	6. Barataria Bay, La.		
Great egret	0.49	Louisiana heron	1.4 A
Louisiana heron	0.42 A	Snowy egret	0.46
White ibis	0.28 A	Great egret	0.43
White-faced ibis	0.27	White ibis	0.12 B
Snowy egret	0.25	White-faced ibis	0.0
Glossy ibis	0.23	Glossy ibis	0.0
	11. St. Marks NWR, Fla.		
Snowy egret	1.9 A	Snowy egret	1.9 A
Bl.-cr. night heron	1.5 A	Louisiana heron	1.4 AB
Louisiana heron	1.3 A	Bl.-cr. night heron	0.68 ABC
Least bittern	1.1	Least bittern	0.48
Little blue heron	0.87 A	Green heron	0.15 BC
Green heron	0.40 A	Yel.-cr. night heron	0.0
Cattle egret	0.24	Cattle egret	0.0
Yel.-cr. night heron	0.0	Little blue heron	0.0 C

Appendix IV (cont.).

DDE		PCB's	
Species	Geometric mean	Species	Geometric mean
12. Cedar Keys NWR, Fla.			
Great egret	1.0	Snowy egret	0.24 A
Snowy egret	0.37 A	White ibis	0.12 A
Louisiana heron	0.21	Louisiana heron	0.12
White ibis	0.12 B	Great egret	0.0
13. Chassahowitzka NWR, Fla.			
Great blue heron	0.46	Great blue heron	0.43
Great egret	0.42 A	Louisiana heron	0.20 A
Bl.-cr. night heron	0.31 A	Bl.-cr. night heron	0.14 A
Louisiana heron	0.15 A	Great egret	0.13 A
16. J.N. "Ding" Darling NWR, Fla.			
Great blue heron	1.4 A	Great blue heron	2.6 A
Great egret	0.98 AB	Great egret	0.65 B
Snowy egret	0.59 AB	Snowy egret	0.29 B
Louisiana heron	0.41 AB	Anhinga	0.21 B
Anhinga	0.41 AB	Bl.-cr. night heron	0.20 B
Bl.-cr. night heron	0.33 AB	Louisiana heron	0.13 B
Green heron	0.28	White ibis	0.0
Little blue heron	0.14 B	Little blue heron	0.0 B
White ibis	0.11	Green heron	0.0
17. Everglades NP, Fla.			
Roseate spoonbill	0.42 A	Roseate spoonbill	0.12 A
Snowy egret	0.19	White ibis	0.0 A
Louisiana heron	0.16 B	Louisiana heron	0.0 A
White ibis	0.08 B	Snowy egret	0.0

Appendix IV (cont.).

DDE		PCB's	
Species	Geometric mean	Species	Geometric mean
	20. Lake Istokpoga, Fla.		
Little blue heron	1.5	Little blue heron	8.4
Snowy egret	0.96 A	Snowy egret	0.46 A
Cattle egret	0.58 A	Louisiana heron	0.19 AB
Louisiana heron	0.50 A	White ibis	0.0 B
White ibis	0.14 A	Cattle egret	0.0 B
	21. Merritt Island NWR, Fla.		
Wood stork	4.0 A	Great blue heron	2.4 A
Great blue heron	2.1 AB	Bl.-cr. night heron	1.8 A
Bl.-cr. night heron	1.0 AB	Great egret	1.5 A
Cattle egret	0.93 AB	Wood stork	1.2 A
Great egret	0.66 B	Anhinga	1.1 A
Snowy egret	0.54 B	Louisiana heron	0.81 A
Green heron	0.49 B	Little blue heron	0.54 A
Louisiana heron	0.49 B	Snowy egret	0.53 A
Little blue heron	0.41 B	Cattle egret	0.53 A
Anhinga	0.39 B	Green heron	0.44 A
Glossy ibis	0.34 B	White ibis	0.21 A
Least bittern	0.29 B	Least bittern	0.17 A
White ibis	0.27 B	Glossy ibis	0.0 A
	25. Blackbeard Island NWR, Ga.		
Great egret	2.1	Bl.-cr. night heron	1.1 A
Bl.-cr. night heron	0.95 A	Louisiana heron	0.28 B
Snowy egret	0.80 A	Cattle egret	0.25
Louisiana heron	0.66 A	Snowy egret	0.21 B
Green heron	0.62	Great egret	0.16
Cattle egret	0.38	Green heron	0.0

Appendix IV (cont.).

DDE		PCB's	
Species	Geometric mean	Species	Geometric mean
	29. Cape Romain NWR, S.C.		
Great egret	2.2 A	Great egret	0.83 A
Glossy ibis	1.5 AB	Snowy egret	0.57 A
Snowy egret	0.79 B	Louisiana heron	0.17 A
Louisiana heron	0.36 B	Glossy ibis	0.0 A
	32. Pea Island NWR, N.C.		
Great egret	3.8	Great egret	1.6
Glossy ibis	1.8 A	Bl.-cr. night heron	0.73 A
Bl.-cr. night heron	1.3 A	Little blue heron	0.35 AB
Snowy egret	1.0 A	Snowy egret	0.29 AB
Little blue heron	0.81 A	Louisiana heron	0.21 AB
Louisiana heron	0.60 A	Glossy ibis	0.032 B
	33. Chincoteague Bay, Md.-Va.		
Great egret	2.4 A	Bl.-cr. night heron	1.8 A
Bl.-cr. night heron	2.4 A	Snowy egret	1.7 A
Glossy ibis	2.0 A	Great egret	1.3 AB
Snowy egret	2.0 A	Louisiana heron	0.97 AB
Little blue heron	1.9 A	Little blue heron	0.83 AB
Green heron	1.1 A	Green heron	0.23 AB
Louisiana heron	0.88 A	Glossy ibis	0.16 B
	35. New Jersey		
Great egret	4.2 A	Bl.-cr. night heron	4.3 A
Bl.-cr. night heron	3.5 A	Great egret	4.0 A
Snowy egret	1.8 AB	Little blue heron	3.1 A
Glossy ibis	1.5 B	Snowy egret	2.3 A
Little blue heron	1.2 B	Louisiana heron	1.3
Louisiana heron	1.1	Glossy ibis	0.29 B
Green heron	0.77	Green heron	0.25

Appendix IV (cont.).

DDE		PCB's	
Species	Geometric mean	Species	Geometric mean
	36. Long Island, N.Y.		
Bl.-cr. night heron	7.0 A	Great egret	8.6
Great egret	2.8	Bl.-cr. night heron	8.4 A
Snowy egret	2.0 B	Snowy egret	7.9 A
Glossy ibis	1.8 B	Glossy ibis	0.59 B
	38. Gould Island, R.I.		
Bl.-cr. night heron	4.5 A	Bl.-cr. night heron	10.0 A
Snowy egret	2.8 A	Snowy egret	3.0 B
Little blue heron	1.3	Little blue heron	2.8
	42. House Island, Mass.		
Bl.-cr. night heron	4.5 A	Bl.-cr. night heron	12.0 A
Snowy egret	3.1 A	Snowy egret	6.1 B

Appendix V

Comparisons of mean shell thickness (μm) in eggs of anhingas and wading birds for eggs collected before 1947 and eggs collected 1947-1973. Basic unit of measurement was clutch mean thickness. N = number of clutches used in computing the mean for a period; n.s. = difference not significant at $P < 0.05$. Differences between periods were not tested if the number of clutches in either period was less than 5.

Appendix V.

Species and States	Pre-1947 N	Pre-1947 Mean thickness	1947-1973 N	1947-1973 Mean thickness	Percent change	Significance level
Anhinga						
Fla.	104	343	45	345	+0.6	n.s.
Ga., S.C.	10	340	0	-	-	-
La., Miss., Tex.	6	352	29	326	-7.5	< 0.05
Great blue heron						
Del., N.J., Pa.	43	407	0	-	-	-
Fla., Tenn.	114	400	33	379	-5.2	< 0.001
Fla. (Keys)	34	402	0	-	-	-
Ill., Mich., Minn., Ohio, Wis.	26	396	36	365	-7.9	< 0.001
La., Tex.	49	403	2	424	+5.0	-
Maine, N.Y., R.I.	24	404	0	-	-	-
S.C., Va.	21	412	0	-	-	-
Green heron						
Ala., Ga., S.C.	42	181	24	179	-1.2	n.s.
Del., Md., N.C., Va.	23	181	10	181	0.0	n.s.
Conn., Mass., N.J., N.Y., Pa., R.I.	122	183	1	183	0.0	-
Iowa, Ill., Ind., Mo., Ohio, S.Dak., Tenn., Wis., W.Va.	45	185	0	-	-	-
Fla.	58	183	41	184	+0.3	n.s.
La., Tex.	12	180	48	183	+1.6	n.s.

Appendix V (cont.)

Species and States	Pre-1947 N	Pre-1947 Mean thickness	1947-1973 N	1947-1973 Mean thickness	Percent change	Significance level
Little blue heron						
Ala., La., Mo., Miss., Tex.	24	245	72	242	-1.3	n.s.
Del., Ga., Md., N.C., N.J., S.C., Va.	18	236	71	239	+1.2	n.s.
Fla.	157	241	39	242	+1.7	n.s.
Cattle egret						
Ala.	0	-	4	232	-	-
Fla.	0	-	67	228	-	-
Ga.	0	-	14	233	-	-
La., Mo.	0	-	4	233	-	-
Md.	0	-	10	228	-	-
Miss.	0	-	13	215	-	-
S.C.	0	-	12	217	-	-
Great egret						
Fla.	83	293	89	295	+0.9	n.s.
Ga., N.C., S.C., Va.	22	298	29	294	-1.2	n.s.
La., Miss., Tenn., Tex.	24	310	31	302	-2.3	n.s.
N.J., N.Y.	3	306	10	291	-4.9	-
Mich., Minn., Ohio	1	291	12	300	+3.2	n.s.

Appendix V (cont.)

Species and States	Pre-1947 N	Pre-1947 Mean thickness	1947-1973 N	1947-1973 Mean thickness	Percent change	Significance level
Snowy egret						
Ala., Ga., S.C.	42	233	36	232	-0.4	n.s.
Fla.	82	228	58	224	-1.7	n.s.
La., Tex.	19	235	40	233	-0.7	n.s.
Mass., N.J., N.Y. R.I.	0	-	71	228	-	-
N.C., Va.	2	230	20	233	+1.0	-
Louisiana heron						
Ala.	0	-	19	229	-	-
Fla. (north)	82	228	58	231	+1.3	n.s.
Fla. (south)	43	232	27	226	-2.9	n.s.
Ga.	14	227	26	236	+3.8	n.s.
La.	48	233	62	235	+1.1	n.s.
N.C., N.J., Va.	1	230	15	239	+3.8	-
S.C.	8	234	14	231	-1.3	n.s.
Bl.-cr. night heron						
Conn., N.Y., R.I.	37	278	39	258	-7.1	< 0.001
Fla., Ga., S.C.	21	287	36	274	-4.6	< 0.01
La.	0	-	26	273	-	-
Mass.	39	286	47	259	-9.3	< 0.001
Md., N.C., Va.	22	292	15	282	-3.4	n.s.
Mich., Ohio	18	286	15	270	-5.6	< 0.01
Minn.	9	279	8	274	-1.8	n.s.
N.J.	50	292	10	256	-12.3	< 0.001
Yel.-cr. night heron						
Ala., Fla., Ga., N.J., S.C., Va.	49	280	23	280	0.0	n.s.
La., Ohio, Okla., Tex.	19	279	21	288	+2.8	n.s.

Appendix V (cont.)

Species and States	Time periods: Pre-1947 N	Pre-1947 Mean thickness	1947-1973 N	1947-1973 Mean thickness	Percent change	Significance level
Least bittern						
Conn., Mass., N.Y., R.I.	21	145	0	-	-	-
D.C., N.J., Pa., Va.	107	147	0	-	-	-
Fla.	62	143	25	140	-2.1	n.s.
Ga., N.C., S.C.	18	143	0	-	-	-
Iowa, Ill., Minn., Mo., N.Dak., Wis.	37	142	2	150	+5.3	-
La., Tex.	8	143	9	143	0.0	n.s.
Mich., Ohio	31	140	0	-	-	-
Glossy ibis						
Fla.	29	322	50	318	-1.2	n.s.
Md., Va.	0	-	12	328	-	-
N.C., S.C.	0	-	20	320	-	-
N.J.	0	-	26	328	-	-
N.Y.	0	-	35	324	-	-
White-faced ibis						
La., Tex.	29	303	16	308	+1.9	n.s.
White ibis						
Fla.	297	349	123	350	+0.3	n.s.
S.C.	9	353	1	323	-8.5	-
La., Tex.	4	361	6	345	-4.4	n.s.

Appendix V (cont.)

	Time periods					
	Pre-1947		1947-1973			
Species and States	N	Mean thickness	N	Mean thickness	Percent change	Significance level
Roseate spoonbill						
Fla.	32	425	7	419	-1.4	n.s.
La., Tex.	15	427	22	427	0.0	n.s.
Wood stork						
Fla.	93	530	20	483	-8.9	< 0.001

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